GROUP OF YOUNG PRIMATES

Behind the table, from left to right are a Chimpanzee, Asiatic human type (Samoyede), European human type, and two Orang-utans. In the foreground, to the left a Gorilla, to the right African human type (Nigerian)

PELICAN BOOKS

THE CHILDHOOD OF ANIMALS

BY

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Prais'd be the fathomless universe,
For life and joy, and for objects and knowledge curious.

WALT WHITMAN.

J'ai l'amour de la raison, je n'en ai pas le fanatisme.

ANATOLE FRANCE.

Then sing, ye Birds, sing, sing a joyous song!
    And let the young Lambs bound
    As to the tabor's sound!
We in thought will join your throng,
    Ye that pipe and ye that play,
    Ye that through your hearts to-day
    Feel the gladness of the May!

W. WORDSWORTH

PREFACE

In the winter of 1911–12 I gave the Christmas course of six lectures adapted to a "Juvenile Auditory" at the Royal Institution in London. The lectures were not written before delivery and were illustrated by lantern slides, specimens and living animals. I tried to interest and amuse my young audience, and naturally in a total of six hours there was time to give no more than a selection of the very different ways in which different kinds of animals pass the period between birth and adult life.

But I became fascinated by my own subject, and afterwards collected and arranged systematically a much larger set of facts. In that process the need for an attempt at interpretation grew, and the book, first published in the end of 1912, became an essay in biological theory. I hope that it still remains simple; but although I retained the title of the lectures, it might be called, more ambitiously and cumbrously, "A Philosophy of Youth in the Animal Kingdom." This new edition has been revised, but I did not find it necessary to change it in any important respect.

P. Chalmers Mitchell.

London.
January, 1940.

CONTENTS

LIST OF ILLUSTRATIONS

CHAPTER I

CHILDHOOD AND YOUTH

We look out on the world with human eyes, and see with little wonder whatsoever is like ourselves. We are born, small and helpless, yet visibly stamped with humanity; day by day we change, but move with certainty in one direction. A few years pass, and from childhood we attain youth, a few more and we reach maturity. The changes affect size and structure, character and disposition, but are so orderly and familiar that we accept them without surprise, and demand for them no explanation. Man is only one of many hundreds of thousands of living species, and living beings are only a small part of the world around us. Is the mode by which man attains manhood universal in the living world, and does the living world differ in this respect from things that are not alive?

The universe throbs with restless change. Our sun with its system of revolving planets is rushing into the recesses of starry space on some errand at which we cannot guess. The little planet that is the home of the only life we know is impermanent in its masses and in its details. The oceans shift on their uneasy beds; continents and islands rise and fall. Mountains and plains are carved and fretted by air and wind and water, blistered by heat, riven by frost and smoothed over by vegetation. The chemical elements of which we used to think as eternal counters, passing unchanged through mazes of combination and disintegration, are, some of them at least, in a process of making or unmaking. Everything that we know is becoming rather than being. None the less there are degrees and differences in change itself. The swift and inevitable routine of life stands in sharp contrast with the vaguer and more capricious rhythms of things that are not alive. All living creatures are born into the world from seeds or eggs or directly from the bodies of their parents, and

unless they meet death by the way, meet it at the end, after passing through childhood and youth, maturity and old age. This orderly progress from the beginning to the end is characteristic of all animals, and the parts of it that we call childhood and youth are the most characteristic. Complicated pieces of machinery, like watches or motor-cars, resemble animals in many ways, and like them may be new or old, but are never young. Youth is a property of the living world.

The history of an animal, from its first appearance as a speck of living matter formed from the parental body, to its death, is continuous, and it would be useless to try to define exactly when childhood begins, when it passes into youth, or the point at which the period of youth ends. There is difficulty even in fixing the beginning, for animals of the same kind may be born at different stages of growth, whilst animals of different kinds differ extremely in this respect. A large black newt, brilliantly spotted with yellow, known as the spotted salamander and common in the south of Europe, lays eggs like the spawn of a frog. But unlike the eggs of the frog which show the presence of tadpoles only after some days, those of the salamander appear with fully formed little tadpoles wriggling in them, and hatch almost as soon as they are laid. Sometimes they hatch actually before they are laid, and it is in the tadpole stage that the animals first appear in the world. So also most snakes lay eggs and incubate them for days or weeks, before the young snakes break through the leathery shell. But in some snakes, like the common adder, what corresponds to hatching takes place inside the body of the mother, and instead of eggs being laid, young snakes are born. Most of the warm-blooded, hairy creatures that we know as mammals because they suckle their young, give birth to moving young and do not lay eggs, but two of them, the duck-billed platypus and the spiny echidna of Australia, lay eggs with yolk and hard shells. The platypus incubates the eggs until they hatch; the echidna, after laying an egg, transfers it with her mouth to a pouch on the under side of her body, like that of a kangaroo, and in this warm and secure receptacle, safer than any nest, the egg is kept until it hatches. Mammals of the group known as Mar-

supials, because most of them have a *marsupium*, or pouch (which is well seen in the kangaroo), at one time laid large eggs and no doubt transferred them with the mouth to the pouch, just as the echidna still does. But now the eggs are retained for a certain time in the body, although the young are still very imperfect when they are born. The new-born young of a kangaroo is less than an inch long, although its mother may be nearly as tall as a man. The figure (Fig. 1)

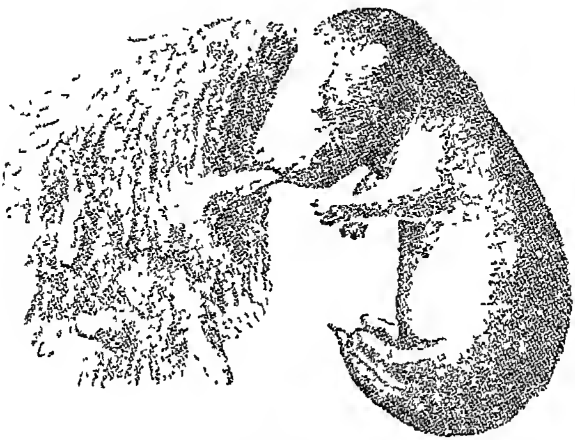


FIG. 1. Part of the inner wall of the pouch of the red Kangaroo, with the young attached to the teat. (Natural size.)

has been drawn from a specimen obtained at the London Zoological Gardens, and shows the naked little creature, an embryo rather than a young animal, hanging to a nipple inside the hairy pouch of its mother. In higher mammals eggs are not laid and the young at birth are much more formed than in the case of the kangaroo, but they may be covered with fur, have their eyes open and be able to run in a few minutes, like young hares, or, like young rabbits, may be naked, blind and helpless.

Young animals can be placed in three groups, notably

different in their character. The first group has little claim to existence: it contains a few animals that have no period of youth. The second group contains very many of the animals with which we are most familiar. The young are sufficiently like their parents to enable us to make a close guess as to what they are going to become. In the third group we must place those young animals, of which many insects and marine creatures are familiar types, that are so unlike their parents that their destiny cannot be guessed from inspection. The changes through which many of these creatures pass on their way to adult life are as strange as if a new-born human baby were to have the form of a fish, swimming in a tank, feeding greedily on worms and water-fleas, and then after a few weeks or months were to grow very fat and sleepy, to split along the back, and, discarding its fish-skin, to creep out on land in the form of a hedgehog; and if the hedgehog were to live for months or years the life of a humble quadruped, growing bigger and fatter until it, too, reached a limit of growth, broke out of its hedgehog skin and appeared as an adult human being fitted in body and mind to be a bishop or a burglar.

Further consideration of the first group need not detain us long. The very small animals known as amœbæ, the largest of which are visible as specks to the naked eye, are mere droplets of granular protoplasm, creeping over the mud in fresh water or in the sea, or lurking in the bodies of other animals or of plants. The soft, jelly-like material of which they are formed makes it possible for little particles of food to be engulfed wherever these come in contact with the surface of the body. The simple business of their life is to creep in search of food, to digest the food as quickly as possible, and to grow bigger. But although the different kinds of amœba differ in size, there is a limit beyond which each kind does not grow. When that limit has been reached, or sometimes before it has been reached—for reproduction is a good deal more complicated in its causes than a mere escape from inconvenient size—the amœba becomes oblong in shape and then acquires a kind of waist which becomes more and more slender until only a string of jelly remains.

Finally, this string divides, and the two halves become rounded again, each forming a complete amœba, exactly like the parent in all respects except size, and these two at once set about the pursuit of food and begin to grow. The two amœbæ may be called young animals in the sense that they have just come into existence as new individuals, but nothing in their tissues or characters distinguishes them from their parent. So far as the period of youth has any interest or significance, these animals escape it. Many small creatures belonging to the lowest group of the animal kingdom, the Grade known as Protozoa, reproduce like amœba by a process of simple division.

The animals in the second group will engage most of our attention in this book, because they include ourselves and those most nearly akin to us. As their structures, habits and dispositions are not very remote from our own, they offer problems which it is possible to understand, and perhaps to solve, and they give a hope of interpreting our own history and of predicting, perhaps controlling, our own future. They have this in common, that the young always resemble the parents more or less closely.

Amongst human beings and monkeys, the young are born in so advanced a condition that we think of them as babies and not as embryos. The eyes are open, the voice is lusty, the face, the hands and feet and the body generally are shapely and well formed. But the senses are deficient, especially in the great apes and man. The hand of a new-born infant will close round and cling to a broomstick or any other object placed in it, almost in the automatic fashion in which the tendril of a creeper will twine round a support which it comes to touch. So also, in the danger of the woods, the new-born gorilla or chimpanzee must cling from the first to the body of its mother, or perish miserably. In a few days the observing and reflecting parts of the brain awaken, automatic action becomes less important, and is replaced by a medley of instinct and intelligence. In the lower monkeys, and especially in lemurs, although the young cling to their mothers, the automatic period is shorter, and the babies, almost from the first, show what looks like conscious, in-

dependent movement. Human babies and the babies of apes and monkeys differ from their parents in proportions. The heads are relatively larger, especially in the higher creatures, and the legs and arms are relatively shorter. They all, as a rule, are born with some hair, but this is more scanty and more different in texture and colour than that of the parents in human beings and the great apes, more like that of the parents, in abundance, texture and colour, in the lower monkeys and lemurs.

I have already said of this group of young animals that although there is a fairly close resemblance with the parents, we cannot always be certain of the particular species to which an infant belongs. The reason of this difficulty lies in the striking circumstance that the young of nearly allied animals are much more alike than are the adults. No one could fail to distinguish a fully grown man, gorilla, orang and chimpanzee, but in many points in which the young of these creatures differ from the adults, they resemble each other more closely. In the slow development of every individual before birth and after birth, the characters of the species are the last to be assumed. We explain this by supposing that the evolution of the individual to a certain extent repeats the evolution of the race. Man, the gorilla, the orang and the chimpanzee had a common ancestor, and the children of these creatures are more like the common ancestor, and so like each other, than are the adults. We have to remember, however, that this explanation is not complete, and we shall find many characters of young animals to which it does not apply. The young animal owes its characters not merely to its ancestry; as much as the adult, it has to be fitted to the special environment in which it lives. It is not merely a stage in development, but an independent living creature with its own needs and its own aptitudes, presenting characters that are neither a memory nor an anticipation, neither a relic of the past nor a preparation for the future, but suitable for its own purposes. These creatures, suckling their mothers, clinging to them and being protected by them, have an environment which is much simpler and more nearly identical than the environment of the adults, and we must expect, quite

apart from common inheritance, to find common characters due to common conditions. The figures on the Frontispiece represent young animals two or three years old, and show how much more alike they are when they are still children

FIG. 2. Head of an unborn Gorilla. (*After* J. DENIKER.)

than when they are grown up. The young gorilla, with its small ears and short upper lip, is not very different in appearance from a black baby; the very long upper lips of the orang and chimpanzee and the large ears of the latter make them rather less human.

The parental stages of man and the great apes are still more alike than are the young creatures. The text-figures of the young gorilla (Fig 2), taken from a specimen of an unborn ape obtained by Monsieur J. Deniker, and of a human being of about the same age. after a figure given by Professor Metchnikoff (Fig. 3), show the almost appalling resemblance between man and the ape before birth. For comparison, I

Fig. 3. Head of a human fœtus, about five months old. (*After* E. Metchnikoff.)

Fig. 4. Head of an unborn long-nosed Ape. (*After* E. Selenka.)

have given in another figure (Fig. 4) a representation of a corresponding stage in the development of one of the lower monkeys, the long-nosed ape of Borneo, taken from a drawing given by Professor Selenka in his great monograph on the embryology of mammals. The faces and features, the domed forehead covering the capacious brain, the practical absence of hair, and every minute detail of the internal and external structure agree with a fidelity that is almost shocking. Professor Metchnikoff was so impressed by such resemblances that he has suggested that the human race may have taken its origin from the precocious birth of an ape. There is a remarkable character displayed by young animals. When

these differ from the adults, it is not merely that they resemble their ancestors, or are specially fitted for the purpose of their own stage of life. They sometimes suggest the future possibilities of the race, directions in which the race may move As the young animals mature they lose promise and flexibility, and settle down to the average characters and average limitations of their kind

Young Carnivores seldom differ notably from their parents.

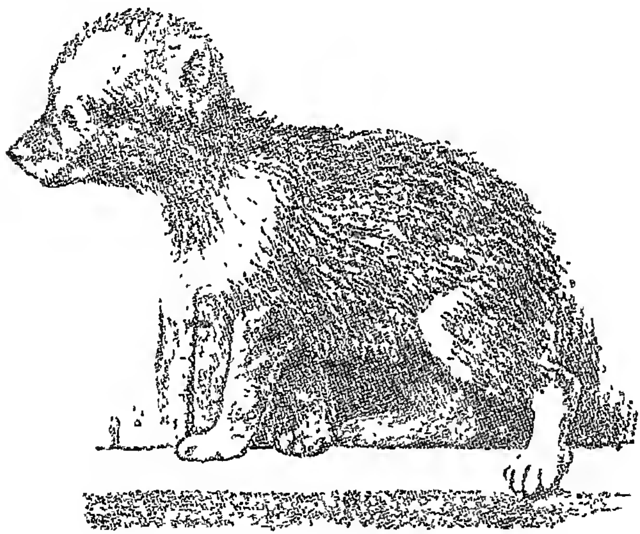


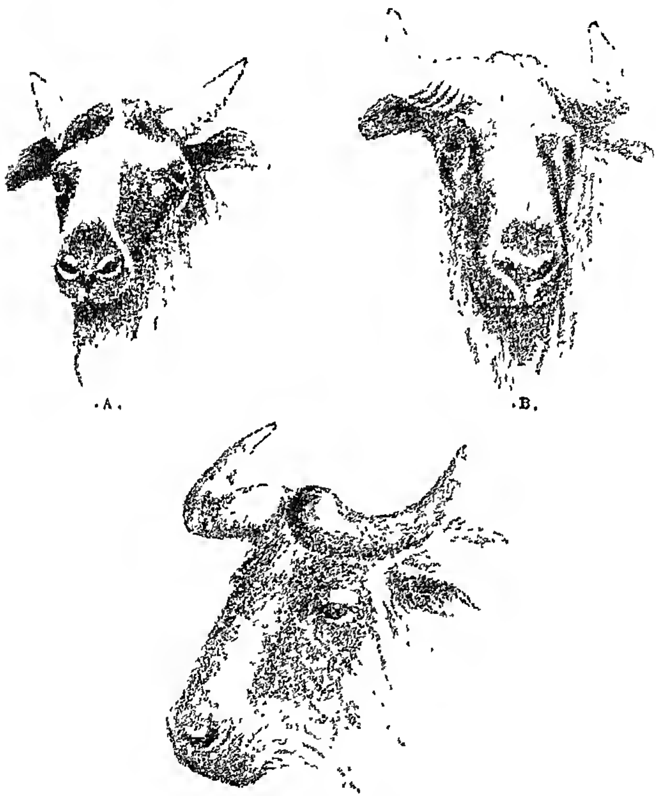
Fig. 5. Young American Timber-wolf.

The cubs of lions, tigers, leopards and jaguars, and the kittens of cats, lynxes and caracals can usually be identified at a glance. They are softer and more rounded, and differ in size and in proportions, and they do not display characters limited to one sex, like the mane of the lion, or special marks like the twisted, hairy tufts on the tips of the ears of caracals and lynxes, and those which are uniformly coloured when

they are adult may be spotted when they are young. The puppies or cubs of dogs, dingoes, wolves, jackals and foxes are much more alike than the adults, and point clearly to descent from a common and not very distant ancestor. Young wolves (the drawing in Fig. 5 represents the cub of an American timber wolf) are quite like the puppies of domestic dogs, except that their ears are erect. The difference is mental rather than physical. When they begin to run about, they betray a shy and furtive disposition, as if they expected no kindness or toleration from man. Young hyænas and civets, bears, raccoons and weasels, seals and sea-lions all closely resemble their parents.

It would be tedious to go through mammals group by group, making the same general statements about them. Differences of colour and pattern in the coat are often remarkable and will be discussed in a separate chapter (Chapter VI). When the adults have no special weapons or ornaments, they can be distinguished from their young by little that is visible, except size. A young hippopotamus, except for the absence of tusks, a young dromedary or bactrian camel, except that the humps are not so conspicuous, and a kangaroo, as soon as it is able to leave the pouch of its mother, are almost ludicrously exact miniatures of their parents. Baby elephants are more interesting. The smallest that I have seen was a female Indian elephant, presented to the London Zoological Gardens by the Government of the Federated Malay States, and certainly less than a year old and about three feet in height. No one could mistake it for anything but an elephant, but it was thickly covered with long coarse hair, recalling its distant relative, the extinct hairy mammoth. Its ears were much larger in proportion to the size of the head than in the adult Indian elephant, so recalling the African animal, and this resemblance was increased by the smoothly rounded forehead, passing in an even curve from the root of the trunk to the top of the head, and showing no sign of the angular forehead of adult Indian elephants. Its trunk was rather short, the tip being well off the ground when the little animal was standing upright, and was rather an embarrassment to it. It found difficulty in finding its

mouth with it, fumbling as a baby does when trying to use a spoon. Nor had it learned to use it in drinking; it sucked its milk by a rubber tube placed in its mouth, holding its trunk awkwardly out of the way. No doubt if we could see



·A.

·B.

C.

FIG. 6. Three stages in the growth of the horns of the Takin. A, at six months old; B, at two years old; C, young adult. (From an example living in the London Zoological Gardens.)

together a young Indian elephant, a young African elephant and a young mammoth, we should find that they were as much alike as are the young of the great apes and man.

A young giraffe from the first resembles its parents, but neither its neck nor its legs are so long in proportion, and the horns, although erect and tufted with hair like those of the adult, are soft because they have no bony core. In the great assemblage of animals that are armed with horns or antlers the peculiarities of these weapons appear gradually, and the young, at first defenceless, produce little straight spikes like those of their fossil ancestors, and these, as they grow larger, curve or twist or branch until they reach the full splendour of maturity. In antelopes, sheep, goats and cattle, where the horns are "hollow," that is to say, where they consist of a horny case fitting over a bony core, the first weapons to appear persist throughout life, however they may increase in size and change in shape. In Fig. 6 some of these differences are shown. The takin, a rare and very large goat-like animal from the highlands of Asia, shows little conical horns when it is a few months old. These are placed rather far apart on the forehead, separated by an expanse of hair. As the horns grow they acquire a spiral, goat-like twist and the greatly expanded lower portions meet in the middle line to form a stout rough helmet. In the eland, one of the largest of the African antelopes, the horns first appear as still more slender conical spikes, and as they grow usually become twisted in a straight spiral in the fashion in which a stick of soft candy can be twisted when one end is held firm and the other rotated. Cattle of different kinds also show small spiky horns at first, and these later on acquire the spreading curves of the adult.

Mammals, when they are born or very soon afterwards, closely resemble their parents. The differences are due to greater likeness to ancestors and to their nearest allies, to the absence of special weapons or ornaments, or to the presence of characters useful to the young themselves.

Newly hatched birds, nestlings and fledglings are usually rather unlike their parents, but none the less fall into the second group of young animals. The shape of the body, the

head with its bill and long neck, the wings, the absence of a true tail, and the single pair of legs with the slender toes leave us in no doubt as to the group of the animal kingdom to which the most naked chick belongs. But I doubt if young birds could be assigned to their proper species as correctly as similar identifications could be made in the case of mammals. For all birds, in the elements of their structure, are closely akin. Even the great families are difficult to separate, and species are distinguished chiefly by external structures and especially by the differences in plumage. Young birds may be naked, and so show nothing of the most distinctive specific character; they may be downy, and the down of many different kinds of birds is alike; and they may assume several successive plumages, none of which are like those of the adult. Although, therefore, they certainly belong to the second group of young animals, the resemblance with the parents is seldom close. Young birds are certainly birds, and very often the group or family to which they belong can be recognised.

When reptiles are hatched or born, they are in a much more advanced state of development than occurs in the case of birds. Not only is there no doubt as to their being reptiles, but they are plainly crocodiles, lizards, serpents or tortoises, and although they may be protected by their parents for a time, they are at once able to move and to feed, and in their appearance and habits are miniature copies of their own parents.

The three groups into which I am placing young creatures do not correspond exactly with the different classes of animals, and the Batrachians (frogs, newts, toads and their allies) and the fishes lie on the border-line between the second and third groups. Some frogs, when they are hatched, appear as little air-breathing, terrestrial creatures quite like their parents, but most pass through a tadpole stage, and tadpoles not only live very different lives from the adults, but differ extremely from them in appearance. So also amongst fishes; some of the sharks hatch in a form so like their parents that they can be at once assigned to their proper family and even species, but the young stages of eels were known and given separate

names as different kinds of fish long before there was any idea that they were young eels.

The multitudinous tribes of animals without backbones, which, in contrast with the Vertebrates (Mammals, Birds, Reptiles, Batrachians and Fishes), are spoken of as Invertebrates, display extremely different types of structure, but agree in usually having a totally different appearance in the young and the adult stages. There are some exceptions: young spiders resemble their parents in the fashion of reptiles and mammals, and here and there the members of an individual family or group of invertebrates, unlike their nearest relations, are hatched in a form differing from the adult chiefly in size. These exceptions are usually cases of animals that have taken to life in fresh water or on land, in circumstances where the kind of young which is found in their nearest allies would have difficulty in surviving. The nearest marine relatives of the fresh-water crayfish, for instance, hatch out as delicate floating creatures which are extremely unlike their parents, but which would be carried away by the currents in brooks and rivers. When the young crayfish is hatched, it is a miniature crayfish which has only to grow and to make a few trivial changes to reach the adult form.

The young animals in the second group appear in the world in a form that is more or less like that of their parents, and reach maturity by increase in size and by a gradual assumption of the full character of the adult. Incidentally they show various structures and characters that are of benefit only in the period of youth and that have probably been acquired for that purpose. In their younger stages they often recall the structure and appearance of the younger stages of their nearest relations, and probably also of the ancestors common to them and to their nearest relations. But these ancestral resemblances are vague and uncertain; the young animals do not wish to display to us their pedigrees, but to become adults as quickly and as directly as possible. Although, however, it appears to be certain that animals do repeat, to some extent, the history of their race in their individual lives, and compress into a few weeks or months the results of countless centuries of evolution, we cannot

expect the repetition to be very perfect. And I think we are led to the curious conclusion that the more directly an animal develops, and the earlier it shows traces of what it is going to become, the less it shows of its ancestral history. The path of evolution which was slowly traced by the ancestors of the animals alive to-day, has been long and tortuous, sometimes direct for a time, often twisting sharply to one side or the other, sometimes, perhaps, even bending backwards. So far as it is possible, animals avoid these devious ways in their individual lives and press on straight to the goal. In the animal kingdom as a whole, and in each of its divisions, the higher types tend to develop most directly and to show least of their ancestral history.

Consideration of the third group of young animals, in which the young stages differ much from the adult stages, requires a separate chapter.

CHAPTER II

LARVÆ AND METAMORPHOSES

THE easiest way to begin to get a picture of the group of young animals which are very unlike their parents is to remember that many animals now live in surroundings quite different from those of their remote ancestors. Although frogs are able to swim well and often are found in water, they are really land animals. They have lungs and breathe air, they hop about on land in search of the beetles and other insects on which they feed, and many of them, especially the green tree-frogs, never readily take to water except at the breeding season, and others even lay their eggs on land. The ancestors of frogs were fish-like animals, living entirely in the water, with gills, not lungs, with a swimming tail and without hands and feet. Probably in the course of a long period of time, and while they were still aquatic animals, some of them began to swallow air in the way that a number of fishes still get an additional supply of oxygen, and probably also some of them had pouches on the gullet into which the air was taken, as in the lung-fishes which still live in the waters of Africa, Australia and South America. Many different kinds of fish crawl on their fins over the mud at the bottom of the water in which they live, whilst others creep out on the edge of the shore and hop along in the surf. It is not at all difficult to follow in imagination the slow changes by which such creatures, living in shallow marshes, became more and more apt for terrestrial life and thus truly amphibious, capable of living in water or out of it. A long swimming tail is an inconvenient possession on land. Newts and salamanders retain it, but are seldom able to move quickly, and the fortunate ancestors of the frogs probably lost it. The modern frog, however, instead of remaining amphibious, makes the change from aquatic life to terrestrial life quickly, in a few days. It hatches out as a tadpole, a fish-like creature with

the head and body in a single mass, continued behind into a long tail which is adapted for swimming by the presence of a thin web above and below. It has no limbs, and little tufts of gills protrude through a slit at each side of the neck. It finds its food in the water, devouring greedily almost any kind of animal or vegetable matter, with a pair of horny jaws made up of a large number of horny teeth closely set together. So it lives and grows for a few weeks. But soon the limbs begin to bud out (Fig. 7), and the lungs develop, while the tail shrivels, and in an extremely short time a number of internal and external changes takes place, and the tadpole

Fig. 7. Advanced Tadpole of a Frog, with the legs visible.

suddenly leaves the water and becomes a frog. Such a striking change, associated with a change of habit, is called a metamorphosis, and the young animal, before it has gone through the metamorphosis, is called a larva. The method of development is plainly a very condensed and quickened repetition of the ancestral history, and the larva is equally plainly the modern representative of a remote ancestor. We must not suppose, however, that the larva is the unchanged image of the ancestor. The tadpole, when it is not swimming, anchors itself to water-weeds by an adhesive apparatus, a kind of sticky sucker, on the under surface of the head, just behind the mouth. We have no reason to be sure that this organ, which differs very much in different kinds of tadpoles, is a legacy from the ancestor; it may equally well be what is called a larval organ, a structure developed for the benefit of the tadpole itself. So also the teeth of the adult frog are true teeth, probably much more like the teeth of the fish ancestor

than the peculiar horny jaws of the tadpole. These, too, may be new organs, developed for the benefit of the tadpole. It is probable, too, that the tufts of gills visible from the outside are new organs of the larvæ, and that another set of gills, lying deeper in the gill-slits, but not present in all tadpoles, is the true ancestral organ of respiration. Every larva is in this way a composite of organs and structures some of which are ancestral, whilst others are new and developed only for the larva. In some cases, like the tadpoles of frogs, the ancestral element is greater, and we may well believe that the larva is a fairly close copy of the ancestor. In other cases, which I shall describe presently, probably the greater part of the larva is new and gives us no true image of the ancestor.

The Batrachians which lose their tails, the Anura, or frogs, toads and tree-frogs, show almost every stage between a true metamorphosis and a direct development. In most of them the eggs are laid in water and true tadpoles hatch out. In some the eggs hatch on land, having been laid in holes, on grass or leaves, and when the tadpoles are hatched, they wriggle into water or are washed into pools by the rain. In others, again, the eggs are laid on land, and the tadpoles have lost their gills before they are hatched, but the metamorphosis is completed later on. In a few the complete change occurs inside the egg, and when hatching takes place little frogs appear, sometimes, however, with a stump of the tail still left. In others the eggs are carried by the parent, and here, too, they may be hatched as tadpoles or as perfect frogs. It would be difficult to find a better example of the gradual change from a type of development which is a repetition of the ancestral history, to the higher type in which the young, as soon as they assume active life on their own account, resemble their parents more or less closely.

The metamorphosis of the tadpole into the frog is a change from a lower to a higher type of life. The larvæ of ascidians or sea-squirts change by metamorphosis into an adult which must certainly be regarded as a lower form of life. The eggs hatch into small tadpoles which swim actively through the sea by vibrating the webbed tail, the latter being stiffened by a simple kind of backbone in the form of a rod of tough jelly.

There is a hollow spinal cord, rather like that in the very young tadpole of a frog, and in the front of this, in the region where the brain of the frog's tadpole is developed, there is a simple kind of eye and ear. Near the mouth there are adhesive organs by which the creature can anchor itself temporarily. The mouth leads into a wide gullet pierced by gill-slits, some of which at least correspond with the gill-slits of the frog's tadpole. At the metamorphosis, the larva fixes itself permanently, at first by the adhesive organs, and afterwards by an outer jacket or test which covers the whole animal with a protecting coat. The tail with its representative of the backbone, the greater part of the nervous system, and the sense-organs, disappear. The gullet and the part of the body surrounding it increase in size, until they make up the greater part of the bulk of the animal. The wall of the gullet becomes transformed into a sieve, pierced by innumerable holes through which the sea-water is filtered, leaving behind the small particles which are used as food. The active, swimming larva, with a structure extremely like that of the lower vertebrates, changes in this way into a hollow bag which sucks in water by one hole and pours it out by another, and which, if we did not know its history, we should find very difficult to associate with backboned animals. How far the larva of the sea-squirt shows a repetition of the structure of its ancestors, or how far its shape and its organs have been formed and adapted for the purposes of its own life, can only be guessed, and different zoologists have made very different guesses. The most usual interpretation is that the larva is in the main ancestral, and that the degradation of the adult is pure degeneration. The sea-squirts are taken to be humble relations of the vertebrates which become degenerate because they had adopted the habit of fixing themselves to the rocks of the coast, and which, in the course of their development, show memories of their high descent. But it is also possible to suppose that their history has been different. It would be greatly to the advantage of animals which are anchored in adult life if their young could move about and settle down in new, less crowded, and perhaps more suitable quarters. The swimming shape is no peculiarity of vertebrates, and this tail

and the directing sense-organs may be new characters acquired for the purposes of the larva.

Flat-fish like the sole and the turbot show a metamorphosis which is more easy to understand, and which occurs when the kind of life led by the larvæ changes to that of the adults. Most bony fishes have what we think of as the usual shape of a fish. They are symmetrical, with the right and left sides of the body alike in shape, colouring, arrangement of the fins and such paired organs as the eyes. Whether they live near

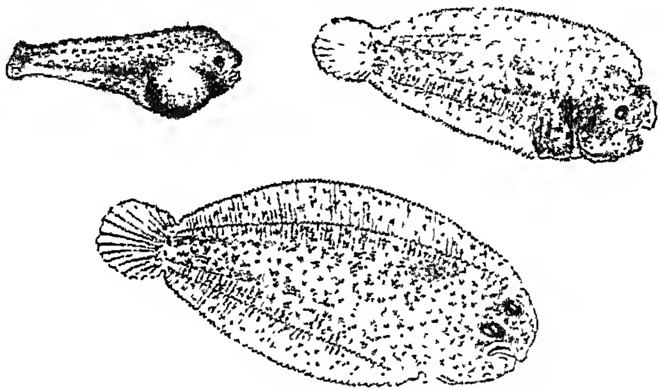


FIG. 8. Three stages in the metamorphosis of the Sole. (*After* FABRE-DOMERGUE *and* BIÉTRIX; slightly enlarged.)

the surface of the sea, or haunt the bottom, they swim in the same sort of position as we do when we are using the ordinary breast-stroke; that is to say, the back is upwards, the under side is downwards. The upper side, too, is much more darkly coloured than the white or very pale under side. The newly hatched larvæ of turbot, brill, halibut, plaice, soles and other flat-fish have this familiar and symmetrical shape and coloration, and when they begin to feed, pursue their small prey in the water exactly like other predaceous fishes. When they have grown to a little less than half an inch in size, however, a sudden change comes about. The right and left sides of

the body become very different. In the turbot and brill the left side, and in the halibut, plaice and sole (Fig. 8) the right side, become dark in colour, whilst the other side loses any pigment it had and is almost completely white. The eye of the uncoloured side rapidly moves, partly round and partly through the head, until it comes to lie near the other eye on the coloured side of the body. At the same time other changes in the shape of the body and the position of the organs take place, so that the symmetrical larva becomes a distorted adult, what we would call at first sight the upper side not being the real back of the animal, but the right side in some cases, the left side in others. When the metamorphosis is complete, the fish changes its habits. Instead of swimming freely through the water, it lurks on the bottom, lying flat on the sand or mud, with the coloured side uppermost. In these cases there can be almost no doubt but that the larva, which is like the great majority of fish, is the ancestral form, and that the change to the adult condition is a condensed and rapid repetition of the slow ancestral history.

The forms of larvæ and the kinds of metamorphoses which occur in marine invertebrates are many and varied, and the few examples I shall choose will serve, I hope, rather to show the interest and difficulty of the subject than to beguile readers into thinking they or I understand them. Echinoderms, of which we all know starfish and brittle-stars, sea-urchins and sea-cucumbers, crawl at the bottom of the sea and show a radiate, generally a five-rayed, symmetry. That is to say, the organs of the body are arranged round a central axis, which is short in the flat echinoderms, such as the starfish and brittle-stars, or long in the globular and oblong ones, such as the sea-urchins and sea-cucumbers, like the spokes of a wheel or the petals of a five-rayed flower. The eggs of most of these echinoderms are very small, and soon after they are shed into the water grow into little floating larvæ. The larvæ quickly assume the shape of a thick-walled cup, the outside of which is covered with small, waving threads of living matter, called cilia, and the hollow of which forms the primitive digestive cavity. The cup grows larger and longer, and its aperture narrows to a small pore. A new aperture breaks through

into the digestive cavity and becomes the mouth; the original aperture sometimes closes up, sometimes remains to form the posterior aperture of the digestive canal. The larva changes its shape, becoming flat, or even concave, on the side where the mouth and anus lie, and remaining dome-shaped on the other. The flat side is now the ventral surface, with the mouth not quite at the front end, the region in front of it

FIG. 9. Larvæ of a Starfish; to the left a Dipleurula, to the right a Bipinnaria, from the ventral surface. (After MORTENSEN; much magnified.)

being called the pre-oral lobe, the anus being nearly at the hind end, and the curved surface being the back, or dorsal surface of the larva. The cilia, which at first covered the whole of the outer surface nearly equally, become longer and stronger on a curved band surrounding the mouth, and nearly, or completely, disappear elsewhere. As there is a front end and a posterior end, a dorsal and a ventral surface, and a right and left side, the larva shows what is called bilateral symmetry, and is called a dipleurula. These larvæ move about in the water rather actively, propelled by the cilia, feed

greedily on floating microscopic plants and animals, and as they grow, change into fantastic shapes, different in the different groups of echinoderms, and so unlike the adult form that many of them were described and named before it was known what they were (Fig. 9). After a few weeks they become sluggish, cease feeding, anchor themselves to rocks or weed, and pass into the adult by a sudden metamorphosis, the details of which differ in different species. It is always, however, only a part of the larva that grows into the adult, the remaining portion shrivelling up, or being cast off. In the starfish, for instance, the attachment takes place by the end of the pre-oral lobe, which forms a sort of stem from which the body of the larva projects, and the young starfish appears on the left side of the larva, the organs of that side forming the greater part of its structure, so that the change from the bilateral symmetry of the larva to the radial symmetry of the adult is itself lop-sided and unsymmetrical.

There can be no doubt but that the greater part of this strange life-history of the echinoderms, which seems more like the fantastic changes of a pantomime than the orderly, deliberate processes of nature, does not represent ancestral evolution. The early stages up to the development of the dipleurula quite possibly recall the structure of some remote and primitive marine creature from which not only the echinoderms but other marine creatures may have descended, for larvæ of a similar type are found in the life-history of many other animals. But the later stages and the curious mode of transformation into the adult occur only inside the group itself.

Polygordius is a small worm which lives in the sand farther out than the lowest tide-mark, rather in the way that an earthworm lives in the garden soil. It is a bilaterally symmetrical, ringed creature with the mouth nearly at the anterior end, with only the portion containing the brain and a pair of sensitive tentacles in front of it. It swallows quantities of sand, passes these through its digestive canal, absorbing any contained food material. The eggs are small, are shed into the water and soon grow into a cup-shaped larva very like the early larva of echinoderms. In the same way, the aperture

FIG. 10. Metamorphosis of Polygordius. Upper figure on left, trochophore larva; on right, later stage with worm growing out; lower figure, much more advanced stage, anterior end. (*After* PARKER *and* ROULE; much magnified.)

of the cup narrows and a mouth breaks through. The larva, however, then changes in a different way. It becomes shaped like a top, with a tuft of sensitive bristles representing the upper pole of the top, the narrowed original aperture, which becomes the anus, being at the lower pole, and the mouth just below the widest part of the body. A band of long cilia, called the velum, passes round the circumference of the widest part of the body, just above the horizon on which the mouth is placed. This larva, which has been named a trochophore and which is totally unlike the parent worm, swims about, feeds and grows, and then suddenly begins to change (Fig. 10). The region round the anus grows out into the long-jointed body of the worm, which hangs down from the floating bell-shaped larva like a tail, and becomes the greater part of the adult worm, soon growing to many times the original size of the larva. The mouth of the larva remains as the mouth of the adult, and the upper half of the larva becomes the region in front of the mouth containing the brain, whilst the ring of cilia disappears. The worm drops to the bottom and begins to be a wriggling burrower in the sand.

The case of Polygordius, which I have taken as an example of many similar cases in marine worms, is very difficult to understand. If the bell-shaped larva, swimming in the water like a transparent jellyfish, represents the far-off ancestor, it baffles the imagination to conceive the stages by which this should have evolved into a creeping worm, by the elongation of the region round its anus. It is much more simple to suppose that the worm developed directly without any floating larva, and that the swimming disk was a secondary development useful, like the wings of a wind-borne seed, to carry the embryo about. If this be correct, the similarity between the Polygordius larva and the larvæ of other marine worms, with the larvæ of animals belonging to different groups of Invertebrates, is, so to say, a mere accident, due to the similar lives the larvæ lead, and with little bearing on the ancestral relationships of these groups.

The large class of Molluscs contains animals of many different types, such as oysters and mussels, whelks, snails

and slugs, cuttle-fish and squids. The period of youth is passed under many different conditions, and especially in those that live on land or in fresh water there are cases which we can see, by comparison with their nearest relations, to be special adaptations to special circumstances. But there are two successive types of larvæ found in so many different molluscs that it seems as if they were at one time stages in the life-history of all molluscs. The first is a small creature (Fig. 11) rather like a minute jelly-fish and very like the

FIG. 11. Larvæ of a Gastropod Mollusc: left-hand figure, a Trochophore; right-hand figure, a Veliger. (Much enlarged.)

trochophore of marine worms, growing from the egg in the same way. It is more globular than top-shaped, and the ciliated band, or velum, is nearer the upper pole, so that the part in front of the mouth is smaller in proportion than in the worm-larva. This rapidly changes into the second type of larva, called the veliger, and peculiar to molluscs. The velum is drawn out into branches or lobes, and the portion in front of it ceases to grow, so that it becomes a mere swimming apparatus carried at the anterior end above the mouth of the larva. The body develops a hump on its back, and this is soon protected by a primitive shell, and, on the lower side, behind the mouth, a flattened mass forms the beginning of the muscular foot, the slimy organ on which a slug or a snail crawls. The veliger gradually assumes the shape of the kind of mollusc in which it is to grow.

It would have required a great deal of elaborate descrip-

tion and the explanation of many details of structure familiar only to advanced zoologists, to give a just idea of the remarkable resemblances between the larvæ of Echinoderms, the trochophores of Worms and Molluscs, and the similar larvæ of some other marine invertebrates. It is tempting to suppose that these different creatures follow the path of a common ancestor while they are living the free-swimming life of that ancestor, and then sharply diverge to reach their different goals. But we have to remember that a metamorphosis cannot be a primitive mode of development, and that where it exists a long history has been blotted out. And we have also to remember that the resemblances of the larvæ are in plain relation to similar habits, and may have no ancestral meaning.

The great class of Crustacea includes crabs, lobsters, crayfish, prawns, shrimps, sandhoppers, woodlice, barnacles and water-fleas and many less well known creatures. Like insects and spiders, they have jointed limbs, arranged in pairs, and the body is covered by a hard external case to the inside of which the muscles are attached, and which is usually known as the shell. Most of them live in or near water, and the terrestrial forms show plain traces of aquatic ancestry. The young of many of them, especially those that live in fresh water or on land, pass through their period of youth in fashions that are quite clearly direct adaptations to the special circumstances of their lives. The marine crustaceans usually lay small eggs which hatch out into larvæ extremely unlike their parents, although the external shell and jointed limbs show plainly that they are crustaceans and betray no resemblance with any other group of the animal kingdom. The larvæ swim about, feed, and after a few days or weeks the hard shell becomes too tight for the plump body, and splits open, setting free the animal, clad in a soft skin and at once swelling to a size rather larger than that of the case from which it emerged. Very quickly the skin hardens to form a new shell, and this second larva is not exactly like the first larva, but rather more complicated, and more near the adult form. The same sequence is followed again, and may be repeated in many successive moults, until a moult comes

after which the young creature has the final form of its species. The seas teem with these larvæ, especially in summer, when the water is warm. They feed on one another, and on the small floating plants which, like the green herbage of the land, are the ultimate food-supply of the living world, and they themselves are preyed upon by hosts of fishes. The larvæ appear in many curious shapes, but in those cases where there are the greatest number of successive larvæ and moults between the egg and the adult, the series shows a rough correspondence with what may be supposed to be the ancestral history of the crustacean in question. In those with fewer larvæ the jumps are bigger, some stages being suppressed, whilst the regularity of the sequence is often confused by the premature appearance of some of the organs or appendages, and the retarded appearance of others. The starting-point in those larvæ in which the series is most complete, and which appears in more different kinds of crustacea than any other larva, is what is called the nauplius. The nauplius (Fig. 12) has an oval body, not divided into rings or segments, with a large median eye on the dorsal surface of the anterior end. It has a mouth on the ventral surface, under the eye, protected by a kind of membranous upper lip, and it has three pairs of swimming appendages, the front pair of which occupy the position of, and correspond with, the antennules or front pair of feelers of the lobster or crayfish. Those of the second pair are forked, and usually have hooks at their bases which lie on either side of the mouth and serve as jaws. They correspond with the antennæ, or second pair of feelers of the adults. The third pair, situated a little farther back, are also forked and correspond with the mandibles or true jaws of the adults. In prawns (of the genus *Penæus*) the nauplius larva (Fig. 12) is succeeded by a larger larva called the metanauplius, in which the swimming parts of the third pair of appendages are smaller whilst a strong jaw portion is developed. Behind, there are the beginnings of four other pairs of limbs. Next comes a protozoëa larva with the same seven pairs of appendages, a carapace or shell beginning to spread over the dorsal surface of the anterior part of the body, and a long, forked, but unjointed

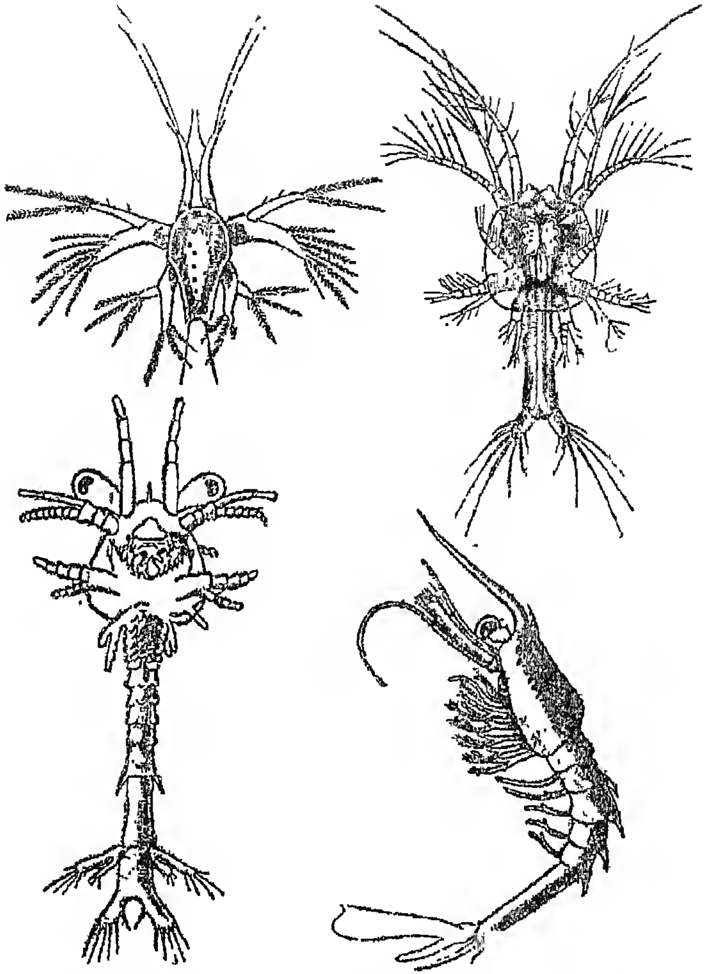


FIG. 12. Larvæ of the Crustacean *Penæus.* Upper left-hand figure, Nauplius; upper right-hand, Protozoea. Lower left-hand figure, Zoea; lower right-hand, Schizopod stage. (*After* F. MÜLLER *and* CLAUS; much enlarged.)

abdomen. The third pair of appendages has ceased to be of use in swimming, and is wholly transformed to the pair of jaws or mandibles. The paired eyes begin to show through the carapace. For several successive moults there is not much change in shape, but the eyes push through the carapace, and the abdomen becomes longer, is divided into joints, and shows the buds of more pairs of limbs. In the next stage, which is called the zoëa (Fig. 12), the paired eyes have become movable, being mounted on long stalks, the carapace projects in front as a long spine, and the abdomen is very long, almost devoid of appendages along the greater part of its length, but with a large pair on the second last segment. After several moults, with further slight changes, a larva appears which is called the mysis stage or schizopod stage (Fig. 12), from its resemblance to the adult form of a lower kind of crustacean. In this stage the projecting spine of the carapace is very long, the abdomen has a complete set of swimming limbs, those of the last pair being large and forming with the last segment itself a swimming tail-fan like that of an adult lobster or prawn. In a further set of moults the complete shape of the adult is acquired by the body and limbs.

In most of the higher Crustacea, the number of moults is smaller, and there are bigger jumps between the successive types of larvæ. The earliest larva of crabs resembles a late stage in the larval development of other crustaceans, the zoëa, but distinguished from them by a long spine on the back. Very soon after hatching, a thin cuticle is cast off, and this differs from the zoëa itself and appears to be the last remnant of one of the suppressed larval stages. Next come a set of larvæ called the megalopa stages, which quickly acquire the appendages and general form of the adult crab, but which have a long extended abdomen. After the moult from which an animal that can first be called a crab appears, the abdomen is tucked up under the body as a rudimentary triangular flap.

Study of the larval development of a very large number of marine crustaceans, of which I have chosen only a few examples, would seem to give a clear picture of the general

course of events. Because they have a hard, shell-like skin, young crustaceans cannot grow larger in the usual way of soft-skinned animals. They must grow in size by a succession of moults. This makes it impossible for the youthful period to be a time of slow and continuous change, from the first larva to the adult. The changes must take place by jumps. Where there are a great many different successive larvæ, each a little more complicated than its predecessor, we seem to see the simplest method of arriving at the result, and the greatest probability that the larval history is at least partly a repetition

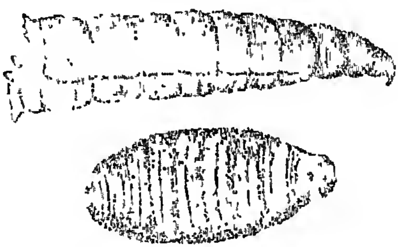


FIG. 13. Larva (upper figure) and pupa (lower figure) of Blow-fly. (*After* LOWNE *and* PACKARD; enlarged.)

of the ancestral history. And the facts that many of these larvæ are closely alike, although they belong to different groups of Crustacea, and that the larvæ of the higher groups not infrequently resemble the adults of the lower groups, greatly increase the probability of this ancestral interpretation being correct.

Insects, like Crustacea, are Arthropods with a hard external skeleton and jointed limbs, and in their development show a series of moults. No life-history in the animal kingdom is more surprising than that of a fly like the blow-fly. The eggs are laid on animal matter, and the flies, no doubt attracted by the smell, prefer matter that is just beginning to soften with putrefaction. The eggs hatch out into the little brown-headed white maggots known as gentles (Fig. 13). They have a pair of strong jaws with which they devour the

animal matter in which they are living, a segmented body clad in a tough leathery skin, and no trace of limbs. They moult two or three times without changing their shape, but growing larger, and soon after the last moult, contract into a quiescent oval body, covered with the skin of the larva which has become dry and brown. After some days passed in this motionless state, the brown skin splits, and the fully formed adult fly emerges, and in a few minutes is winging its

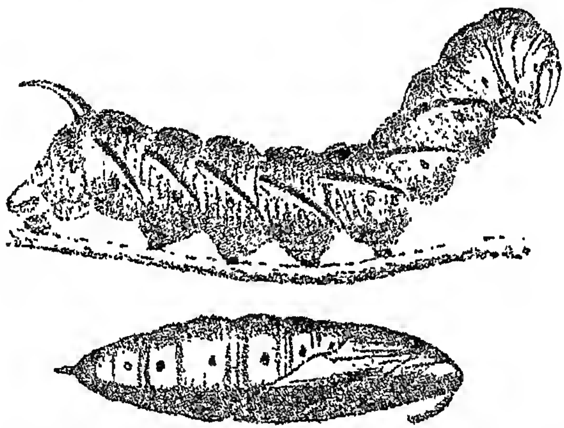


FIG. 14. Caterpillar (upper figure) and Chrysalid (lower figure) of Privet Hawk-moth. (Slightly reduced.)

way through the air, as unlike the worm-shaped larva as any creature could be. With the exception of the nervous system and parts of some other organs, it seems as if the whole of the organs inside the hardened skin of the larva melted down and became rearranged to form the very different organs of the adult. Patient and extremely difficult dissections, however, have shown that there is an intelligible order in this transformation. Some time before the fly emerges it is surrounded by two delicate and transparent skins. The inner of these, if we could imagine it taken out whole, plumped out with air, and dried, would have the appearance of a fly with

a head bearing antennæ, eyes and mouth organs, a body with small wings and six-jointed legs, and a pointed abdomen, but with all these organs and parts, and especially the wings, not quite like those of a modern fly, but rather simpler. This skin is the pale ghost of a former metamorphosis, of a true moult once passed through by the ancestors of the flies, but now on its way to be suppressed. The outer thin skin is the similar remains of a still earlier moult, and its structure, although still fly-like, is less fly-like than the inner skin.

The development of a moth such as the well-known privet hawk-moth carries the story a little farther. The eggs are laid on the privet and hatch into caterpillars which feed on the leaves. The caterpillar (Fig. 14) has a head and a jointed worm-like body. The head has six simple eyes, a pair of three-jointed very small antennæ, and biting jaws. The first three segments of the body carry each a pair of five-jointed clawed legs, corresponding with the legs of the adult insect. Four of the other ten segments carry each pair of larval legs, called prolegs, and not represented in the adult, but entirely for the purposes of the larva. The caterpillar feeds and grows, and moults three or four times. Before the last moult, it becomes restless and wanders about, ceasing to feed. It is ready for pupation, and is seeking a suitable place. Some caterpillars suspend themselves to the branch of a tree or to a projecting point in a dry crevice. Others spin a cocoon of silk. Others, such as the privet hawk-moth caterpillar, descend to the ground and scoop out a dry burrow. There the last moult takes place, and the pupa or chrysalid (Fig. 14) emerges, and very quickly becomes hard and brown. If it be examined closely, however, it can be seen to resemble a moth more than a caterpillar. It shows the shape of the head, body and abdomen of the moth and carries the appendages of a moth, not of a caterpillar, and is provided with short, folded wings. These are at first free, but soon, before the skin has become dry and brown, are glued down with a sticky secretion. The pupa is able to wriggle, but remains practically motionless while the transformation to the adult is taking place. In the course of this there is a suppressed moult, shown by the presence of a very thin skin covering

the body of the moth inside the pupa-case, like one of the two skins in the blow-fly, and like these representing an almost forgotten moult. When the moth emerges, it is ready to fly as soon as its wings have expanded and dried, and it is extremely unlike the caterpillar. But the gap is not so great as in the blow-fly. In the first place, the pupa or chrysalis is much more like the moth than the puparium or skin of the blow-fly larva is like the blow-fly. In the second place, the caterpillar, with its antennæ, eyes and three pairs of jointed,

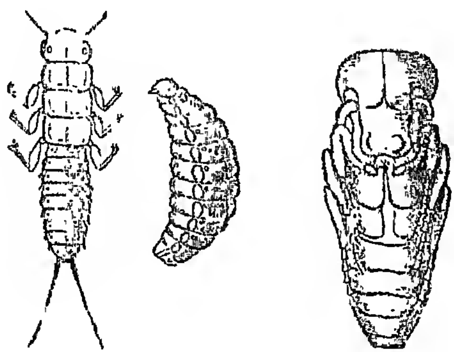


FIG. 15. Larvæ and Pupa of the Oil-Beetle. Figure to the left, Campodeiform larva; middle figure, maggot-like larva; figure to the right, pupa. (*After* PACKARD; much enlarged.)

walking legs, is much more like an insect than is the legless maggot.

Some small insects of which the oil-beetle is a good example expand the contracted history of the higher insects still more. The eggs hatch out into active larvæ showing a head bearing eyes and antennæ, a body of three joints each bearing a pair of fully formed clawed legs, and a jointed abdomen with a pair of long bristle-like projections behind. These larvæ (Fig. 15), although they have no wings, are insect-like in form, and are called Campodeiform larvæ; no one observing them for the first time could doubt but that they are insects of a primi-

tive kind; moreover they are extremely like the members of the lowest group of existing insects, the Aptera or wingless insects, of which the silver-fish and the bristle-tail are well-known examples. These larvæ run about, climb up flowers and have the instinct of clinging to any hairy object. If a bee comes their way, on a visit to a flower, they at once seize hold of its hairy body. If it is an unsuitable bee, they perish, but if it is the right kind for their purpose (*Anthophora* or *Andrena*) they are carried to the nest of their host, and when the bee lays an egg in a cell, the larva slips off and climbs on the egg which is floating in the honey. The larva eats the contents of the egg and then moults. The second larva which comes out is much less like an insect than the first; it is a fleshy grub, not well divided into head, body and abdomen, and with three short pairs of legs. It is intermediate between the degenerate maggot of the blow-fly and the caterpillar of the moth. This grub floats in the honey and devours it and then moults once more, a still more degenerate motionless form appearing, with no movable appendage on the head and with only six stumps in the place of the legs. This in its turn moults and changes to a pupa rather like the adult in form, with the appendages and rudimentary wings glued down to the body. After a resting stage this pupa opens and the adult insect emerges.

The eggs of other beetles may hatch out either as campodeiform larvæ, or as maggot-like larvæ, which, after moulting, produce pupæ with rudimentary wings. The eggs of many other insects, such as cockroaches and earwigs, hatch out as campodeiform larvæ, and then by a series of moults slowly acquire the adult form without any true metamorphosis.

Finally, there are many insects, such as the locusts, in which the earliest stages have been suppressed and there is no sudden metamorphosis, but the period of youth is occupied by a series of moults (Fig. 16) in which the successive larvæ slowly assume the characters of the adult, the wings gradually growing longer.

I do not wish to suggest that the examples I have chosen represent actual stages in the evolution of insects. They have been selected from insects that are by no means closely

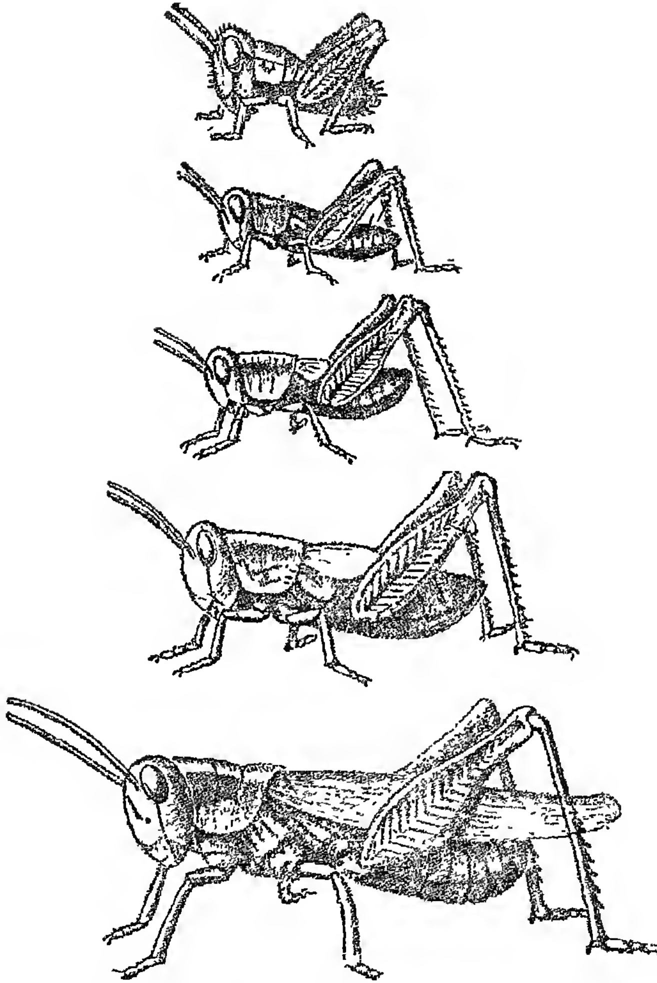


Fig. 16. Development of a Locust. The upper figure, showing the youngest stage, is considerably more enlarged than the others, which are all magnified to the same scale. (*After* Packard.)

related, and they do no more than give an idea how the extremely different modes in which modern insects develop show a trace here and a trace there of different parts of a common ancestral history, some parts of which have been blurred and condensed in some insects, other parts in others. The delicate and transparent pupal skins surrounding the fly inside its puparium, with their rudimentary wings, and the pupal cases themselves of moths and oil-beetles with their rudimentary wings, plainly represent the active later larval stages of the locust. The campodeiform larvæ of the oil-beetle and of many other beetles, cockroaches and earwigs represent the primitive insect, and may pass by a series of moults into the adult, or these later stages may have been condensed to a sudden metamorphosis. The caterpillar-like larva is a rather degenerate modification of the Campodea larva, and the maggot-like larvæ of many beetles and the legless larvæ of flies are still more degenerate interpolations in the life-history, fitting the special conditions in which these larvæ live.

The stories of the youthful period in the crustaceans and insects are, to a certain extent, alike. The hard nature of the skin has led to a replacement of the more usual method of continuous growth, by growth in little jumps, there being a moult at each jump. In both there are many animals in which these successive moults separate a set of larvæ which are becoming more and more like the adult by slow stages. In both the more continuous sets of larvæ seem to be at least a partial repetition of the ancestral history, but in both the larvæ are modified in many ways to suit the needs of their own life, and it is a difficult judgment to decide in any case how much of the character of a larva is adaptive and how much ancestral. In both groups the continuous series may be interrupted at any point by the obliteration or telescoping of some of the stages, with the result that occasionally a moult is preceded by a resting phase in which the larva is more or less torpid and motionless, and when the form that emerges from the moult is widely different from the preceding form. Such bigger jumps give rise to the familiar metamorphoses, and they are most frequent and most decided when

they are associated with a change in the habits of the creatures before and after the metamorphic moult.

There is one striking difference between the two groups. Amongst insects the campodeiform larva, which is certainly the most primitive, represents the most primitive group of living insects, and, moreover, helps to link insects with another group, the group of centipede-like animals. In Crustacea, the nauplius larva, which is certainly the most primitive, does not represent any living group of Crustacea and does not link the Crustacea directly with any other group. Unlike the Campodea larva which, but for the absence of reproductive organs, has the appearance and characters of an adult animal, the nauplius larva is plainly an immature creature.

When Darwin first convinced naturalists that the living world as we see it now had come into existence by a process of evolution, the resemblance amongst the larvæ of different animals, the resemblances of the larvæ of one set of animals with the adults of lower animals, and the parallel between the larval development and the possible ancestral history were thought to provide almost clear proof of the fact of evolution and to show the actual path of evolution. But although increase of knowledge has strengthened the general case for evolution to such an extent that a reasonable naturalist can no longer doubt it, we are getting more wary as to particular cases. The struggle for existence amongst larvæ is extremely severe; of the multitudes that are hatched, only a few reach adult life, and then only after having escaped almost incredible dangers. And so larvæ have been shaped and moulded, coloured and armed in a multitude of ways that fit them to the conditions in which they live. And in this process they must have lost much of their inherited ancestral characters and must have acquired many delusive resemblances.

CHAPTER III

THE DURATION OF YOUTH IN MAMMALS

In the civilised races and especially in the more intellectual classes, the somewhat indefinite transition from youth to manhood does not occur till after the age of twenty. No doubt there are racial differences as well as differences of civilisation and of class, and in the case of Europe the long-headed, dark-skinned peoples along the northern shore of the Mediterranean, although they may be equally civilised, mature at rather earlier ages than the round-headed peoples of Central Europe or the long-headed, fair-skinned natives of the North. But amongst these, too, the period of youth is stretching out, and we may fairly say that youth in civilised man lasts for at least twenty years. Exact observations on the lower races of man relating to this point are not very numerous, but there is a general agreement amongst those with knowledge that both males and females of the lower races mature much earlier. Probably it would be fair to set down from twelve to fifteen years as the duration of youth in most of the lower human races.

The animals that approach man most closely in size and structure are the anthropoid or man-like apes. Gorillas, which live in the tropical forests of West Africa and the high mountains of the Congo Free State, are larger than human beings. They are much more bulky, and their legs and arms are longer. A full-grown male, if it stood perfectly upright, would be considerably more than six feet in height. Chimpanzees, which live in the same parts of Africa as the gorilla, but also extend much farther to the east, have long arms and legs, but are not so large and heavy, and even if fully upright would seldom reach five feet in height. Orang-utans, which are natives of Borneo and Sumatra, have relatively longer legs and arms than the others, but are even less upright. The largest orang is not more than just over five

feet in height, but the great bulk of their bodies exceeds that of ordinary human beings and is intermediate between the bulks of the gorilla and chimpanzee. The gibbons, of which there are many species, ranging over a large part of tropical Asia, are much more erect in posture than any of the other anthropoid apes, and their arms and legs are extremely long. Their bodies are slight, and the largest specimen of the largest species probably is not more than four feet in height, and is therefore smaller and lighter than a human being.

The gorilla, the chimpanzee and the orang avoid the neighbourhood of man, and although gibbons are less shy, their life, passed chiefly in the tall trees of forests, makes careful and prolonged observation difficult. We have, therefore, no exact knowledge of their breeding habits, or of the duration of their youth in the wild condition.

Anthropoid apes seldom breed in captivity, as most of them are taken when they are very young and do not live to maturity. Unfortunately, also, it is certain that little reliance can be placed on the rate of growth of the apes in captivity. Better accommodation, less coddling and more reasonable food are certainly improving the general health of captive apes, and probably their rate of growth is often more natural than it used to be. But we have still to rely chiefly on comparisons with human beings, based on size, the appearance of puberty, the closing of the skull bones, changes in the teeth and so forth, and there is no reason to be certain that such comparisons are not misleading. It is generally assumed, however, that the duration of youth in anthropoid apes is from eight to twelve years, and the estimate is probably not very far wrong.

The lower monkeys range in size from the large baboons, which exceed gibbons in bulk and weight, to tiny monkeys like marmosets which may be no larger than a small squirrel. Although on the whole they are also rather delicate in captivity, so many have been kept by private persons or in public institutions that it is not surprising that there have been frequent successes. Many different species have been bred in captivity and reared to maturity. The larger monkeys, like baboons and mandrills, take from eight to twelve years

to grow up. Middle-sized monkeys, like common Asiatic macaques, take from three to five or six years. The small American monkeys, such as marmosets, become full grown in from two to three years.

The length of the period of youth thus becomes shorter and shorter as we descend from the highest human types to the lowest monkeys, and is parallel with some other qualities of this group of animals. The potential longevity, the age to which an animal can attain under the most favourable conditions, is greatest in the higher races of man, where it may be a century, seldom exceeds fifty or sixty years in the lower races of man, and, so far as the somewhat scanty evidence at our disposal goes, decreases as we pass down the scale of monkeys from the man-like apes to the simplest little monkeys. It cannot be said, however, that there is any definite proportion between the length of youth and the length of the whole life. The span of a complete life is not divided according to any ideal rule or law into so many parts for helpless infancy, so many for aspiring youth, and so many for maturity. Each portion varies with the particular needs of the particular species, and no more is to be expected than that the mode of division should be rather more alike amongst species that are nearly related, and rather less alike amongst species that are far separate.

There is also a rough correspondence between the duration of youth and the size of the creatures in the man-monkey group. A full-grown male gorilla, it is true, is larger, although not taller, than a finely built man, but the human race as a whole consists of larger and finer animals than the anthropoid apes, whilst these in their turn exceed the baboons, which exceed the ordinary monkeys of India and Africa, and so on down to the tiny marmosets. It is tempting to suppose that it must take longer to grow into a big animal than into a little animal. This also is true only when nearly related creatures are compared. Mere increase of bulk tells us little. A mushroom grows much more quickly than a daisy, a gooseberry and a huge vegetable marrow take nearly the same time to swell out. A human child takes nearly two hundred days to double its weight at birth, whilst new-born mice

quadruple their weight in twenty-four hours. The nature of the organism, the complexity of its structure and the particular conditions under which it lives must all be taken into account, and are of more importance than actual size. Within each group of nearly related animals, the duration of youth is in rough agreement with the possible span of the whole life, and with the relative size to which the members of the particular species attain. But the agreement is not exact. There are very many instances in the animal kingdom, and I shall mention some of them, in which there is no reasonable proportion between size or the potential longevity, and the duration of youth.

The descending scale from man to the lowest monkeys, which is fairly plain in the case of size and longevity, is quite certain if we take into consideration the complete structure and especially the mental capacities of the members of the series. When animals belonging to different groups are compared, it is not very easy to say which is to be regarded as higher and which lower. Most persons would agree that the cats, including the large cats like the lion and the tiger and the small cats like the domestic cat, are the highest of the carnivorous animals. But is a cat a higher or lower animal than an elephant? Inside a group, however, comparison is easier, and, especially if we take into consideration the size and structure of the brain, there is no doubt but that man stands supremely at the head of his tribe and that there is a rapid descent from him to the lowest monkeys. The most certain and the most important feature about the differences in the duration of youth, and what is specially clear in the case of man and his relations, is that the length of the period of youth varies with the degree of intelligence to which the adult can attain. Civilised man is the most intelligent and takes longest to grow up; the smallest monkeys are the least intelligent and hurry over the period of youth most quickly.

As a good many of the Carnivora have bred in captivity, we have a fairly extensive knowledge of the duration of their youth, although it is to be remembered that the new conditions to which they are subjected may have an effect on their rates of growth, probably accelerating it. Lions and

tigers take only from three to five years to become adult; both sexes are capable of breeding and the males have got good manes soon after they are three years old, but they may go on growing for several years after that. Leopards, lynxes and caracals, and the smaller cats generally, take from one and a half to three years to become adult. Caracals are a good deal smaller than jaguars or leopards, and their cubs are nearly full grown when they are a year old; probably from one to two years is the duration of their youth. Bears take longer to grow; brown bears require nearly six years, and Polar bears still longer to become adult. The fur seal has been observed very closely in its breeding haunts, and it has been ascertained that it is not adult until it is four years old, but both sexes and especially the bulls continue to increase in size after that age. Among domestic dogs there is almost an exact parallel between size and the duration of youth. They all mature quickly, but mastiffs are hardly mature at two years old, large hounds and greyhounds at about eighteen months, pointers and setters at from eighteen to fifteen months, whilst fox terriers are adult at about a year and toy dogs at even less.

Badgers are born in February or the beginning of March and remain with the mother until the autumn, when they look after themselves. They are practically adult at a year old, but may continue to grow for another six months, the males, as in most mammals, taking rather longer to fill out. Otters are born in almost any season of the year and are adult in about ten months, but may continue to grow for a few months longer. Weasels, martens and polecats all take from nine to eighteen months to reach their full size.

It is impossible to arrange Carnivora in a scale extending from the highest to the lowest in the fashion which can readily be done with man and monkeys. They are all animals of a high type and all show considerable intelligence, power of adapting themselves to new situations, acquiring likes and dislikes to individuals and showing their distastes and preferences in the plainest way. I believe it is the experience of every one who has been at the pains to make friends with any of the wild Carnivora that they show as much intelligence as

the domesticated forms. There is no parallel between size and intelligence among Carnivora; the sizes to which the different species attain seem to be associated with their habits of life rather than with their place in the scale. Youth lasts longest in some of the larger forms; in all of them it is shorter in proportion to size than in man and his allies, and in most of them it is absolutely shorter than in most of the near relations of man. If the two groups be compared with regard to size, the difference is very striking; the largest carnivores, such as bears, lions and tigers, are much larger, more bulky and more powerful animals than gorillas and chimpanzees, but reach maturity much more quickly.

The vegetarian terrestrial mammals belong to distinct groups which are not at all closely related and which must be considered separately.

Elephants are the largest and heaviest of existing land animals. They grow slowly; the duration of their youth is from twenty to twenty-four years, a very much longer time than that occupied by the youth of any other terrestrial mammal except man. If, however, we remember that a full-grown elephant weighs as much as fifty full-grown men, and that these animals have some difficulty in obtaining the enormous quantities of food they require, the length of their youth is not so remarkable. I think that their intelligence has been not a little over-praised. They have good memories, and take strong likes or dislikes to individuals, but those best acquainted with them disbelieve the familiar stories as to their saving the lives of their keepers and so forth.

There is no group of living animals closely related to the elephants, but it is probable that the hyraces, rock-rabbits or dassies are their nearest allies. The largest of these animals is not much bigger than a hare, and there are different species found in Syria, Arabia and Africa. As they practically never breed in captivity, not much is known about their youth. I had a young West African tree-hyrax brought to me which had been taken by its owner when it was in his opinion only a few days old, and which at six months old was not half grown. It is probable, therefore, that the youth of these animals lasts more than a year. It made itself at home in my

house at once, exploring everything, climbing up the legs of chairs and on the shelves of bookcases, generally making a low chirping purr. It liked rubbing its fur and especially the white hair along the glandular patch on its back against my clothes. When it was angry it stamped with its fore-paws on the ground. It had quite an unusual degree of character and intelligence, and a most restless curiosity,

The Odd-toed Ungulates, the rhinoceros, the horse and the tapir, have a period of youth the length of which is roughly in proportion to the size of the animals, but which is relatively rather shorter than that of the elephant and the hyrax. A young rhinoceros grows very quickly at first and runs with its mother until it is nearly full grown. The limit of size varies a good deal in the different species, and actual growth appears to go on for a great many years, but so far as can be ascertained the animals are adult at seven or eight years of age. Horses and asses have been much influenced by domestication, and the period of youth has been made shorter in some of the breeds. Horses, asses and zebras are certainly adult at five years of age, and the average duration of the period of youth is less, probably from three or four years. Tapirs mature very quickly; the duration of their youth is said to be under a year, a very short time for animals of their size, but certainly some individuals at least continue to grow for much more than a year. The rhinoceros and the tapir are rather unintelligent animals with low mental powers. The horse has been so much modified by association with man and by selection for special qualities which are useful or pleasant that we are disposed to have a false idea of its mental powers. I rate them low as compared with monkeys, carnivores or even elephants.

The Even-toed Ungulates have a still shorter duration of youth in proportion to their size. Those that do not ruminate, the hippopotamus and the swine and peccaries, have often bred in captivity, and we have therefore accurate information about them. The hippopotamus is a very large animal, a good male reaching over 14 feet in length and weighing well over 4 tons. They are fully adult in five or six years, although they may continue to increase in bulk for some time after

that. Swine of different kinds come to maturity in from eighteen months to two years, although they also may continue to increase in size for a longer period. The hippopotamus is certainly a stupid animal, and I do not believe in the intelligence of pigs. The tricks of trained animals, such as the learned pigs of country fairs, are very simple adaptations of their natural instincts, and are no evidence for the existence of any real mental capacity.

The Ruminating Ungulates without exception have a very short duration of youth in proportion to their size, and could be arranged in an almost regular series in which size and duration of youth were parallel. Giraffes are the largest, and their period of youth lasts from six to seven years. Camels are adult in three years, llamas and alpacas in rather less. Domestic cattle are adult in about two years. Bison take between two and three years, and increase in size for rather longer. The very large deer like elk are adult in two years, but may continue to increase in size for a longer period; whilst in them as in other deer, although there may not be much increase in actual size, the antlers become more spreading and acquire more points for many years after maturity has been attained. Elands, which are the largest of the antelopes, are mature in three to four years. Many of the little duikers reach their full size and are adult in about twelve to eighteen months. The range of the period of youth in the whole group of ruminants lies between seven years and one year and follows the size of the animal rather closely. It will be generally agreed that ruminants are animals of low intelligence.

We have not much information as to the duration of youth in the marsupials. The large kangaroos leave the pouch of the mother permanently in from six to seven months. They grow very quickly immediately afterwards, and are fully adult in from one to two years. The smaller forms develop still more quickly and are fully adult in from six months to a year.

Rodents differ much in size and in intelligence. Beavers are not the largest members of the group, but they are larger than most, and much more intelligent than any of the others.

They begin to pair when they are two years old and are fully grown at the end of the third year, so that the duration of their youth may be reckoned as being between two and three years. Hares may begin to breed when they are a year old and are fully grown in fifteen months. Rabbits have a shorter youth; they pair when they are from five to eight months old, and are fully grown in a year. Guinea-pigs may begin to breed when they are three or four months old and are full grown in from five to six months. Rats, which are born naked and blind, are covered with hair on the eighth day, and are able to see on the thirteenth day. On the twenty-first day they have reached the size of a house mouse, and are turned out to shift for themselves when they are thirty-nine days old. They begin to breed when they are less than six months old and are fully grown a few months later. Mice will breed when they are six weeks old and are fully grown at three to four months old.

I do not think that it is necessary to go on giving any more examples. It is clear that different kinds of mammals pass through very different periods of time in growing to adult life. There is certainly some relation between size and the duration of youth. On the whole it takes a longer time to grow into a big animal than into a small animal. But the relation is not so close that it can be explained in a simple fashion. The youth of civilised man and of the elephant lasts about the same number of years. A common monkey and a lion take about the same time to grow up. The North American beaver and the bison take very nearly the same time, although the latter is several hundred times the bulk of the former. Nor is there any part of the processes of nature which might lead us to expect an inseparable link between time and bulk. The different cells and tissues of the individual body grow at different rates, and these rates may change at the call of circumstances that have nothing to do with size. Temperature, moisture, the nature of the food and many other agencies alter, retard or accelerate the pace. There seems to be a very wide range within which the same organs and tissues or the same kinds of animals or plants may grow more quickly or slowly. None the less, it is

reasonable to suppose that closely allied animals have more or less similar constitutions, and such a conclusion is supported by many physiological observations. They have similar habits, they react in similar fashions to the same diseases, and betray their community of blood by responding to similar environments in similar ways. And so comparisons between the duration of youth and the size of the adult are less misleading when they are made inside the various groups. I have shown that on the whole the larger animals of a group take longer to grow up than the smaller animals of the same group. But the parallel is not exact, and there are many exceptions, as, for instance, among the Carnivora. On the other hand, the higher, the more intelligent members of a group are usually the larger animals. Here again there are exceptions, but on the whole it is true of living groups and of the total procession of life in the past. Mammals form the highest class of living animals, and amongst mammals are to be found the largest existing members of the animal kingdom. In the age of Reptiles, when they were the lords of creation, the largest existing animals were reptiles. In the age of Batrachians the largest existing creatures were batrachians. And so inside the orders of living mammals, they are, on the whole, the most highly organised creatures that have been able to increase in size. Certainly there are many advantages in being big. A bulky animal can resist changes in temperature better than a smaller creature, which may be more quickly overheated or chilled through. A big animal, other things being equal, is more powerful and can protect itself better and travel greater distances than a smaller animal of the same kind. But there are also great disadvantages. A big animal needs more food than a smaller one, and can less easily escape the observation of its enemies. The struggle for existence is specially keen among animals with similar habits and structure, and amongst these it is the more highly organised and intelligent that can become large with least risk. Amongst mammals I do not doubt but that the apparent connection between the duration of youth and the size is secondary; both depend on intelligence. It is the more intelligent animals that have the longest period of youth.

Breeders of domesticated animals have found that they can prolong or shorten the duration of youth in the case of farm stock. There are many instances showing that wild animals in captivity mature more quickly in some cases, more slowly in other cases, than their fellows under natural conditions. The series of animals in the different orders of mammals show that there is an increase in the duration of youth as we pass from the lower forms to the higher forms. Putting these different sets of observations together, we must draw the conclusion that the rate of growth in animals has been altered in the course of evolution, and in such a fashion as to prolong youth in the higher forms. This lengthening of youth is not completely explained by increase of size, nor even by increased complexity of structure. Its advantage is that it gives the opportunity for education in the widest sense of the word, a space for experiment and for the replacing of instinct by intelligence.

CHAPTER IV

THE DURATION OF YOUTH IN BIRDS AND LOWER ANIMALS

It is a curious fact that in proportion to their size, birds are longer lived, or at least have a higher potential longevity, than mammals. Passerine birds, which range in size from minute creatures which, stripped of their feathers, are no larger than the tiniest shrew-mouse, to the large ravens, have a potential longevity ranging from twenty to sixty years. Owls and parrots certainly can live for half a century, and eagles and vultures much longer. Pelicans and storks may live for from fifty to thirty years, ducks and geese much longer, pigeons and gulls for thirty years. ostriches for fifty years. Compared with these figures the duration of youth is always short, and is remarkably constant; it varies from about one year to nearly four years. There is very little relation between size and the length of youth. As the intelligence of birds is very remote from that of our own, it is most difficult to estimate which are higher and lower in this respect. But on the whole it must be said that birds are much more instinctive than mammals, that their various duties are performed in a more rigid and mechanical fashion, and that there is therefore less need than amongst mammals for the experimental period of youth.

Reptiles live to great ages. They grow very slowly and many of them appear to go on growing throughout their lives. The rate of growth, moreover, is much more dependent on surrounding conditions. particularly on temperature. Reptiles, like batrachians, fishes and probably most, if not all, invertebrates, have not a normal body temperature, but go up and down with the temperature of the air or water with which they are surrounded and are thus almost at the mercy of the elements. If they become too hot or too cold they first get torpid, and if the conditions continue they die.

Reptiles will not feed or grow unless they are kept warm. In the varying conditions of nature, a succession of warm seasons or of cold seasons must affect the rate of growth of reptiles to a very large degree, and it is not surprising that we can tell little of the age of any individual from its size. Very few reptiles breed in captivity, whilst in the wild condition their shy habits make it difficult to observe them closely. There is the further difficulty that young reptiles from the first are remarkably like their parents. And so it happens that we have practically no information regarding the duration of youth in reptiles.

The sizes to which the different species of frogs, toads and newts may reach vary within wider limits than those of birds and mammals, but it is curious that the range is narrower, especially in the case of the tailless land forms, than occurs with reptiles. Batrachians are less shy in their breeding habits than are reptiles, and many of them have been bred and reared in captivity. In the case of those that breed in water and pass through a metamorphosis, the spawn is usually laid very early in the year, but this depends partly on temperature. The tadpoles of the common frog begin to leave the eggs in about five days, and in about two months the legs have appeared, whilst the metamorphosis is complete and the frogs leave the water in nearly three months. The development of the common toad is not quite so rapid. The tadpoles leave the eggs in about ten days, but the two pairs of limbs are not fully formed for about eighty days, whilst the young toads leave the water relatively smaller than frogs, when they are a little more than three months old: They may begin to breed long before they are full grown, but they take from three to five years to reach the normal size. The possible duration of their life is unknown, but they have so many enemies that probably few have the luck to reach old age.

Fish, like reptiles, grow slowly and may live to great ages. In them, as in reptiles, although there are species which may reach a large size and species the members of which are always small, there is a very wide range of size for each species, and growth appears to go on continuously throughout life. As in the case of reptiles, the rate of growth varies

with external conditions, partly those of temperature, but still more the nature and amount of the food-supply. The eggs of fish take from about three to over a hundred days to hatch out, but the time varies a good deal according to the temperature of the water. As a rule the eggs of smaller fish hatch more quickly than those of larger fish, but a more important difference depends on the size of the egg. Small eggs with very little yolk hatch quickly, and the larvæ on their appearance are in a more rudimentary condition. Those with an abundant supply of yolk take longer to hatch, but the larvæ are relatively larger and more highly developed. As cold water delays development and retards the period of hatching, the larvæ usually appear when the water is warm and when there is an abundant supply of the microscopic organisms on which they feed. Growth is then rapid and in most cases the larvæ become transformed into small fish like the adults in the course of their first season. The subsequent history varies much in different kinds of fish. In those where the larvæ and the adults live under practically the same conditions, the sexual organs often mature next season, and although the fishes may be small, their period of youth is over. Often there is a migration from inshore water to deep water, to the bottom of the sea, or, in the case of fresh water, from the shallow fringes of lakes or from upland streamlets to deep water or to the lower parts of rivers, and the change to adult life may take more than a season.

In fishes where there is a complete change of habitat the youth may be further prolonged. The larvæ of the salmon, called parr or samlets, are hatched in the spring in the fresh-water pools where the spawn has been deposited. They remain in the rivers usually for about two years, slowly losing their youthful uniform of red spots and dark bars and acquiring a silvery colour. In the spring of the third year they go down to the sea as smolts, which display a much darker and more mottled coloration than salmon. In the sea they rapidly mature, becoming silvery all over and developing their sexual organs. They then ascend the rivers to breed, and their duration of youth is thus at least three years, although from the great change of size, a smolt weighing

only a few ounces and a grilse four or five pounds, it has been supposed that the young fish may remain more than a single year in the sea. The fresh-water eels migrate to the sea to spawn and lay their eggs at great depths. These hatch out into ribbon-shaped larvæ with very small heads. These little fish have been known as Leptocephali for many years, the different kinds of them receiving different specific names before it was discovered that they were the larvæ of different kinds of eels. The larva of the common eel, formerly known as *Leptocephalus brevirostris,* grows rapidly until it becomes about two and a half inches long, when it passes through metamorphosis and becomes transformed to a small eel, which, curiously, is only about two inches long. These small eels leave the bottom of the sea and come up towards the coast when they are about a year old. They then enter fresh water, ascending the rivers in great numbers, and at night migrating from stream to stream across wet grass. They live for a number of years before they become adult, the largest size to which the females attain being a little over a yard, that of males being much less. Then the sexual organs begin to develop, the process taking several months, during which the eels cease to feed. They then migrate down to the sea, and when they have reached deep water, probably more than a hundred fathoms, spawning takes place and the eels die. This is a curious instance, very unusual amongst vertebrate animals, but common in insects where nearly the whole life of the animal may be occupied by the period of youth. It seems to be the case that eels spawn only once, and that however long they live, or whatever size they attain, they must be regarded as still in the youthful period until they have ceased to feed and have begun to spawn.

All the vertebrate animals have a structure not remote from our own, a nervous system consisting of a brain and spinal cord, and organs of smell, sight and hearing essentially similar to our nose, eyes and ears. Amongst them we are on familiar ground, and have some reason to suppose that we can interpret their mental operations and emotions with a sympathetic intelligence. The bond is most close between us and the higher monkeys and gets more and more remote as we

pass through the various orders of mammals and descend through birds to reptiles, and from them to batrachians and fishes. Fear and anger, cowardice and bravery, dislike and affection, the relations of individuals to individuals and of species to species, may differ in quality and degree, but appear to be essentially similar in kind in all these different sets of animals. They are all in mental touch with their environment in the same sort of fashion. I think that we must be right in interpreting the phases of their life by the same kind of standards that we can apply to our own case. The duration of youth in all is settled by no invariable chain of organic necessity. It has no relation to the duration of the complete cycle of life from birth to death. It is linked with size, but only in an indirect fashion, most apparent in animals most akin. It is linked much more closely with complexity of organisation, so that the higher forms usually take longer to mature than their near but lower relations. It is linked most closely with intelligence, the more intelligent animals having relatively longer youth. And as we pass downwards from intelligence to instinct we find that the duration of youth shortens.

The duration of life of most insects is limited to less than a year. The eggs hatch out when the temperature has become sufficiently high, the larvæ grow bigger, pass through their metamorphoses and become transformed to the adult in the same season. The life of most of the adults ceases when the cold of winter comes on, if it has not been arrested sooner; but the species maintains existence, either because the eggs are laid in a position where they may lie dormant until next spring, or because a few of the adults hibernate in some sheltered place. Sometimes the total life is limited to a very short part of a single season. In many of the plant-lice, for instance the little green flies which plague the gardener, the total life lasts only two or three weeks. The eggs are laid, the larvæ are hatched, mature, become adult, and die all within a month. The total life of common flies such as the blow-fly and the house-fly is a little longer. The blow-fly hatches out in twenty-four hours, the larva takes a fortnight to grow, whilst the metamorphosis within the pupa case takes

a fortnight in warm weather, and much longer when it is cold. The normal life of the adult fly is from a few days to a few weeks, or in specially favourable circumstances, a few months. The length of the larval life of butterflies and moths varies according to the size, the habits and the weather, and as in extreme cases the life of the adult may last a good many months, it is possible that the total cycle may sometimes extend a little over a year. Amongst bees, the larval life and the metamorphosis occupy at most a few weeks, whilst the life of the adult is relatively longer. Worker bees never live beyond the year in which they are produced; whilst the life of drones may be only a few days, and is never more than a few months, as towards the end of the season, when honey is getting scarce, they are driven out of the hive to perish. Queen bees may live from two to five years; they are fed and cared for by the workers, and their confinement to the hive after the nuptial flight preserves them from the vicissitudes of the weather.

The instances that I have given do not show any great eccentricity in the distribution of the total duration of life between the youthful and the adult stages. In very many insects, however, the disproportion between adult life and larval life is so great that adult life appears to have been reduced merely to the time required for reproduction. Many adult moths and butterflies have no mouths and do not feed. The males live only long enough to meet and fertilise the other sex, and the females live a little longer, apparently only because they have to seek out food-plants or places specially suitable for the larvæ which will hatch out from the eggs they lay. The eggs of the mayflies are dropped into the water and in a few months hatch out into creeping campodeiform larvæ. These live, according to the species, from six months to three years in the water, and then come up to the surface, usually creeping out on the banks. The larval integument then splits open and a creature which has the form of a winged insect and seems able to fly emerges. This, however, goes through another moult, generally within a few minutes or hours of the first moult, and the perfect insect appears and takes to flight. Its mouth organs are rudimentary

and it is incapable of taking food, and dies generally three or four hours after its emergence, in this brief space of time having met the other sex and performed the duties of reproduction. Dragon-flies similarly lay their eggs in water; the larvæ live from one to two years, and then, coming to the surface, go through metamorphosis. The perfect insects are predaceous creatures with powerful jaws; they hawk and devour smaller insects, but the total duration of their adult life is at most a few months. In many beetles the disproportion between the duration of youth and of the adult is still more remarkable. An extraordinary case is that of the seventeen-year cicada, a North American land bug. The adult insects are heavily built creatures nearly an inch and a quarter in length, with two pairs of transparent wings. The mouth-parts are imperfect and the creatures do not feed, living only two or three weeks. The eggs are laid in slits cut in the bark of trees, and the larvæ, soon after hatching, burrow into the ground, where they live on vegetable matter. They grow slowly, moulting five or six times in the first two years of their life. In the seventeenth year they leave the ground, burrowing up through the surface soil or through hard-trodden paths, and after hiding for a time under stones and sticks, crawl up trees, where they undergo the final moult, from which the perfect insect emerges.

These various cases of the shortening of the adult life until it leaves time only for reproduction must be secondary adaptations, for it cannot be supposed that creatures with the elaborate structure of winged insects could have come into existence without the capacity to feed, and the extreme instances are connected by a chain of intermediate forms with insects possessing a more normal balance of the periods of life. Winged insects have many enemies; they are fed upon by all manner of reptiles, birds and mammals. Weismann has suggested that the pressure of the struggle for existence is so great that it has become of importance to them to get through the business of reproduction as quickly as possible, and that those insects have survived best and so have been favoured by natural selection in which sexual maturity most quickly followed the attainment of the adult form. What at

least is certain is an association between the acceleration of reproduction and the shortening of the adult life. When the next generation has been provided for, the adults have accomplished their mission in life and are no longer required. Whether they die from exhaustion, or because their tissues have an inherently limited duration of life, or because they are unable to resist the attacks of poisons from without or from within, may some time be solved. To me it seems most probable that the influence of natural selection has worked through speeding up the process of reproduction, until that occurred so quickly that it almost certainly would have taken place before the various accidents from within and from without destroyed the adult. Creatures subject to great destruction by other animals, creatures that had little powers of resistance to microbes, or that were specially liable to die because of the inherent delicacy of their constitutions, would become extinct unless they reproduced as soon as possible. Among a very large number of different animals there are wide individual differences in the time when sexual maturity occurs. Stock-breeders have taken advantage of this natural variability, and have produced breeds which become mature at unusually early ages when the object is to grow animals for the table as cheaply as possible, or breeds that mature later when the object is to secure special strength and stamina; and it seems extremely probable that similar changes have come about under natural conditions, according to the needs of the particular species. The postponement of reproduction lengthens the period of youth, and gives a greater opportunity for education before the absorbing responsibilities of adult life have been assumed. The acceleration of reproduction secures that a species which has many enemies should leave abundant progeny, although it may actually lead to a degeneration of the structure and qualities of the adults.

Among insects generally there is a kind of division of labour between the larval and the adult stages. In the larval period the chief functions of the body are feeding and growth, whilst in the adult condition the chief function is reproduction. As we have seen, this division of labour may

be carried so far that the adult is incapable of feeding. There are some extraordinary cases, however, where reproduction takes place in the larval state, with the result that the adult state is dropped altogether. The gall-midges are very small two-winged flies, the larvæ of which live on the tissues of plants, sometimes doing great damage, the Hessian fly, which attacks wheat, being a familiar example. The adult females

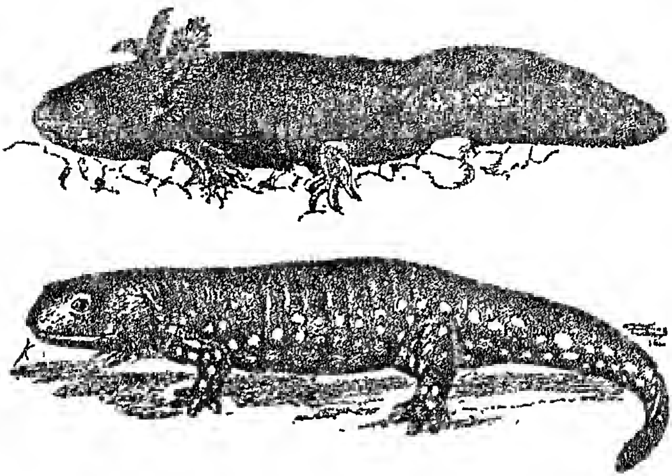


FIG. 17. Metamorphosis of Axolotl. Upper figure, the aquatic axolotl; lower figure, the terrestrial amblystoma.

of most of these flies lay eggs on the plant, and these hatch out into minute grubs, which, after a time of feeding and growing, pass through metamorphosis and produce the adult winged insects. In one or two cases, however, it has been found that the ovaries are developed actually in the larvæ and that these produce young which live on the tissues of their parent and finally leave it by boring a hole through the skin. The parent in such a case dies without having become a perfect insect.

Similar instances of reproduction before the larval state

has been passed through occur as rare exceptions in several groups of the animal kingdom, but the best-known examples are found in the batrachians. The youthful stage of most of these animals, as I have described in Chapter II, is passed in water, the young animals being tadpoles. A celebrated case is that of the Mexican axolotl (Fig. 17). These animals occur in large numbers in lakes near Mexico City, where they form an important article of food. They are dark-coloured, tadpole-like creatures which when fully grown are seven to nine inches in length, and possess a swimming tail with a fringing fin above and below, with the usual two pairs of limbs with fingers and toes, and with three pairs of gills projecting from the sides of the neck. They are quite hardy. and are familiar objects in aquaria in Europe, where they breed freely. They were supposed to belong to the division of batrachians which are known as Perennibranchiata, as they retain their gills and the aquatic habit throughout life. In 1865. however, some young axolotls, bred in the Jardin des Plantes at Paris, gradually lost the gills and the fin along the back and tail. The gill-slits closed up, the head became broader, and the animals left the water permanently. The black skin became blotched with spots and streaks of yellow, and it was soon recognised that a metamorphosis had taken place, that the axolotl was not an adult perennibranch, but the larval form of a well-known salamander, *Amblystoma tigrinum* (Fig. 17). A German lady, under the direction of two professors at the University of Freiburg, proceeded to make a set of careful experiments, and found that it was possible to induce young axolotls to change into the adult amblystomas, the most successful method being to keep them in very shallow vessels so that they had a frequent opportunity of breathing air, and at the same time to make the normal gill-respiration inconvenient by securing that the water should have less than its proper quantity of dissolved air.

The curious facts as to larval reproduction in the axolotl throw a possibly new light upon the relations of the different groups of batrachians to each other. It had been assumed that the Perennibranchiata, those which remained aquatic and had gills throughout their life, were the representatives of a

primitive stock, and that in the same way the gilled larvæ of the terrestrial adults represented an ancestral stage passed through in the actual development of the modern forms. It is clear, however, that the external gills do not correspond with the primitive fish gills, and that the limbs with fingers and toes correspond with terrestrial rather than aquatic conditions. If the occasional metamorphosis of the axolotl had not been discovered, the axolotl would have been classed with the other perennibranchs. It is quite probable that the other perennibranchs are creatures which have actually permanently lost their terrestrial adult condition, and so are degenerate rather than primitive. It has been suggested even that the ancestors of the living batrachians were terrestrial creatures, breathing by lungs and with two pairs of limbs with hands and feet possessing fingers and toes, and that the aquatic larvæ with their external gills were new interpolations in the life-history. If such a theory were justified, then the perennibranchs, instead of being an ancestral set of batrachians, would really be more modern than the terrestrial forms, and their greater simplicity would be due to the loss of the adult stage.

The progress of evolution is not invariably associated with advance in structure, and it is quite possible that some of the groups which we now think of as being primitive and as possibly representing ancestral stages in evolution are merely larvæ, to which the power of reproduction has been shifted backwards, and which in consequence have permanently lost their adult stages. From this point of view the curiosities of youth which I have been describing would have a great importance in the theory of evolution.

CHAPTER V

COLOUR AND PATTERN IN ANIMALS

It very often happens that young animals, even although they may closely resemble their parents in structure, wear liveries with different colours and patterns. A full-grown lion is nearly uniformly brown; his coat is rather paler on the under parts, and his mane and tail-tuft may be tinged with black; and some individuals, especially lionesses, may show very faint traces of spots. But lion-cubs are spotted animals. The American tapir is very dark in colour, almost black all over except for a white line round the edge of the shell of the ear; the Malayan tapir is parti-coloured, the head, fore-quarters and legs being black, but with a great saddle of white covering the hinder part of the back and passing down under the ventral surface. Young tapirs for the first two or three months of their existence are vividly striped and spotted with white, and the pattern of the Malayan and the American forms is almost identical. Red deer are coloured almost uniformly reddish-brown, except for a light patch or disk on the rump, but the young fawns are conspicuously spotted. There are few living creatures so brilliantly coloured as the male birds-of-paradise. But the upper parts of young males are clothed with sad-coloured brown, and their chests and under parts are banded and mottled with a paler brown. Sea-gulls are brilliantly patterned birds, the general effect being black-and-white, the chest and under parts being white, and the head being covered with a cape or mantle of black or dark grey. Young sea-gulls are at first white, spotted with black and brown, and then covered with a speckled coat of brown, excessively unlike the conspicuous pattern of the adult. I shall give many more examples later on, but for the present it is enough to state that a difference in colour and pattern between the young and the adult is extremely frequent amongst animals.

Colour and pattern, or the combined result of colour and pattern which is usually called coloration, are subjects that have attracted the attention of naturalists from the earliest times, and before discussing the special cases of young animals it will be convenient to set down some general ideas on the matter. There is no side of zoology that has been more fertile in producing theories; many of the greatest

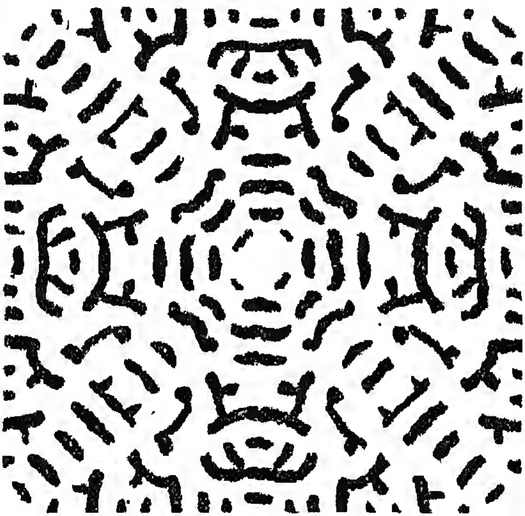


FIG. 18. Repetition Pattern obtained by tearing holes in a sheet of folded paper and then unfolding it.

naturalists, and the lesser naturalists almost without exception, have written on the subject, and I do not doubt but that every person who will read these lines has made or will make confident theorics of his own. I hope, therefore, to proceed warily, and to describe some of the most characteristic facts rather than to select among the existing theories, or to provide a new one. If we take a sheet of thin paper and fold it first into two and then into four, then double it diagonally

from the central corner, then tear, however roughly, a few holes in the folded edges, we shall find on unfolding it again that we have formed a symmetrical pattern, radiating from the centre of the sheet (Fig. 18). If we take another sheet of paper, fold it across so as to make a guiding crease along the middle, and then unfolding it, write a name in ink with a thick pen along one side of the crease, then quickly fold it

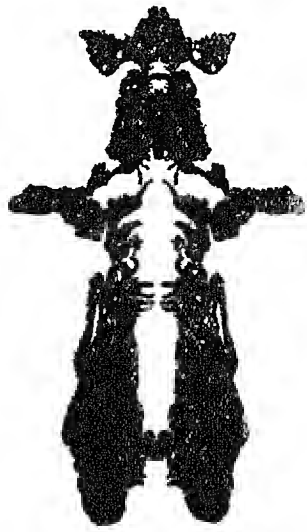


FIG. 19. Bilateral Pattern obtained by folding wet handwriting; the actual words written were "Royal Institution."

over and press it down before the ink has dried, we shall find we have made another kind of pattern (Fig. 19), this time not radially symmetrical round a central point, but bilaterally symmetrical on the two sides of the crease, and more complicated in detail because of the different thicknesses of the ink we left to be doubled and the unconsciously different pressures we gave when folding over the paper on the wet ink.

All visible things must have colour, and so also it is inevit-

able that animals must have colour. The colour may be due to one of several causes or to a combination of causes. Many hues, especially those with metallic sheen, depend on the structure of the surface on which the light falls, the white light being broken up in the process of reflection. When a piece of transparent glass or ice is powdered it becomes white like snow, and this appearance is due to the total reflection of the light from the mixture of little solid particles and intervening bubbles of air. The white of animal tissues is produced in this way. The fur and feathers of arctic mammals and birds, white patches on the skin and so forth come about because there are little bubbles of air or of some other gas entangled in the structure of the tissue. The blues and greens of many birds and insects which do not change in colour according to the angle at which light is reflected from them, and the still more vivid metallic iridescent colours which change as they are moved about, and which are conspicuous in the eyes of the peacock's tail and in the bright tints of birds-of-paradise, are due to a combination of structure and pigment. Frequently there is a dark pigment underlying a transparent layer, forming a kind of mirror, and the play of colours comes from the varying incidence of light and the varied sculpturing or thickness of the transparent layer.

Other colours may be due to the presence of pigments—that is to say, actually coloured substances. Blues and greens occasionally, reds, yellows, blacks and browns almost invariably are pigmentary. The brilliant crimson of the feathers of the turacos is not only a pigment, but one that is soluble in soft water, and is washed out in a heavy shower of rain. A less well known case is that of the black colour of the Malay tapir. If the hand be rubbed over the dark portion of the body a black, greasy stain comes off, whilst the grey part of the body is devoid of this secretion. In some of these cases, perhaps in most of them, the pigment has a direct physiological importance, as, for instance, the red colour of blood, due to the presence of hæmoglobin, the substance which carries oxygen to the tissues; or some of the greens and yellows, which are products of the chemical changes of the body, and are waste matters on the way to be removed; or

blacks, which also not infrequently are products of excretion. Blood was red long before the colour became a visible ornament of the body. So also the black lining of the body-cavity in many reptiles, the brilliant greens and golden yellows of the gall-bladder, the vivid green of the bones of fishes like the South American lung-fish, are clear instances of strongly marked colour, for which, were they visible externally, we should attempt to find an adaptive explanation, to interpret in the light of suitability to the surrounding conditions. Precisely as in the case of pattern, we must not be too certain that colour has a direct purpose. Colours may be useful, and often are turned to use, but their utility may only be secondary, a laying hold of something that was already there. All warm-blooded animals radiate out heat, varying in amount with the physical activities and structure, and if our eyes were sensitive to heat-rays we should see heat patterns and speculate as to their purpose. Finally, the presence of colour, whether it be due to structure or to pigment, makes pattern more conspicuous, while the existence of pattern calls attention to differences of colour.

Colour, pattern and the combination of colour and pattern that we call coloration are to be expected everywhere in the animal kingdom, as indeed in the living world. They are the visible expression of the complex nature and of the mode of growth of living things. All organisms increase in size by the multiplication of parts, and the simpler they are the more mechanically geometrical we must expect them to be. As they become more complex in structure, the primitive and yet more startling symmetry of their patterns becomes altered by irregular growth, by excess in some parts, retardation in others, and by interference of the growth of different systems or centres. Structurally every body is a mosaic, but it is a mosaic which has grown by the growth and multiplication of the separate pieces at different rates. It must have pattern. The different pieces and systems of pieces must have colour, and as they become different in their functions, inherent differences in colour, and differences due to different reactions to the coloured fluids and substances that pervade the whole, cause a still greater diversity. And so coloration is an inevit-

able outcrop, which may or may not be useful.

In natural history all general rules are dangerous, but there is none safer than that it is seldom an advantage to an animal to be conspicuous. It is a hungry world, and there is nothing more generally useful than not to attract attention. The lowest grade in the evolution of coloration is when pattern that is the direct expression of structure and colour—that is to say, the direct result of the chemical processes of the body —is retained. This grade is to be expected in primitive animals and in the young stages of animals, and, whether it be brilliant or dull, is retained in higher types when it is not disadvantageous. The second grade is the smoothing over and partial obliteration of growth-pattern and the toning down of natural colours. This condition is the simplest mode of producing concealment by inconspicuousness, in conditions where the first grades of colour and pattern are disadvantageous. The third and highest grade is when the structural pattern is overlaid by a new pattern, often with very little relation to the natural growth and symmetry of the animal, and where the colours do not appear to be the direct result of the ordinary physiological processes of the body. This third grade is found in the higher groups of animals, and is more frequent in adults than in the young, and in males than in females. As we shall see, even although it may be vivid and brilliant, it may yet secure inconspicuousness in the natural environment of the animals. These three grades must be taken as a help to remember and understand coloration, and not as an absolute set of divisions into which the facts fall, or into one of which any particular fact can be placed with complete certainty.

As the cases in which it appears to be an advantage to animals to be conspicuous are relatively few, I shall begin with them. Many animals, and especially males, wear their bravest livery as a marriage dress, and however they may be coloured at other times, are resplendent at the approach of the breeding season. Differences in coloration of the sexes are not frequent amongst mammals, although the males are more usually distinguished by their powerful weapons of aggression. But the coloured patches on the skin in many

monkeys are brighter and more conspicuous in males, and differences in colour and pattern mark the males of many deer, antelopes and small carnivores. These male ornaments are usually intensified during the breeding season. In birds such differences are almost the rule, and are directly associated with the breeding season, which in many cases is preceded by a moult, after which the sexual plumage is assumed, or the colour of the naked parts intensified. Everyone knows that the cocks are most highly ornamented in such familiar examples as the fowls and pheasants, the peacocks, drakes, male ostriches, birds-of-paradise and so on. But there are also birds in which the sexes are so much alike that it is almost impossible to distinguish them except by observation of their habits, as in the case of pigeons, partridges, most parrots, owls, birds-of-prey and many of the small singing birds. There are even a few odd cases where there is a conspicuous difference in coloration and the females are the more resplendent. This happens in phalaropes, some button-quails, painted snipes and cassowaries, and it is curious that in these cases the usual disposition of the sexes is reversed, and the females are pugnacious, aggressive and courtiers of the males. The sexes are usually alike in reptiles, but male lizards may be brightly coloured when the breeding season approaches. Amongst batrachians there are many in which the sexes are alike, but male newts assume a brilliant nuptial coloration. Whilst the males and females of most fishes are alike in colour, there are many well-known examples of males becoming more brilliant in the breeding season. Butterflies, moths, beetles and bugs, and dragon-flies may be clad in sober or gaudy tints, and are frequently alike in the two sexes, but where there is a difference it is almost invariably the male sex that is conspicuous. In spiders, again, the males are not infrequently more brightly coloured than their mates. The interpretation of such sexual coloration is very difficult. In some cases, especially those of insects where the sexes are alike, bright colours belong to some other category of coloration, or, as Darwin suggested, may have been acquired in one sex and then transmitted by inheritance to both sexes. In other cases they may be the mere expression of exuberant

vitality, of active physiological processes, and may be of no special utility so far as the attraction of the sexes is concerned, but may have been retained in the brilliantly coloured males because their presence was not disadvantageous, and suppressed in the dull females where it was of advantage to the next generation that the female should be inconspicuous during her laying of the eggs and guardianship of the young. But there remain a large number of cases where one sex, almost invariably the male, is always conspicuous during the breeding season, whether that occupy the whole adult life or be a recurrent episode. In such cases it certainly seems to be an advantage to the male to be conspicuous, and there is no better interpretation of these facts than that given nearly seventy years ago, with the most judicial reticence, by Charles Darwin in the "Descent of Man and Selection in Relation to Sex." Darwin showed that in very many cases where the males were conspicuously coloured, they flaunted their colours and patterns before the female, excited her attention by them, and gave her the opportunity, consciously or unconsciously, of preferring the most vividly marked. Sexual conspicuousness, however, is a subject which does not specially concern young animals, and it would be outside the purpose of this book to discuss the theory of it at length. But it is interesting to notice that where adult males are specially conspicuous, so differing from young males and females, the latter usually resemble each other and together resemble more primitive forms. This seems to suggest that the sexual coloration is an instance of my third grade of coloration, and is a relatively late acquisition, a thing imposed on the more primitive patterns and colours. It is to be noticed also that in a great many cases sexual coloration does not conform with the growth and structural lines of the body, but has much of the character of an artificial addition.

It is quite possible that females may not exercise a conscious preference in favour of conspicuous males, and that none the less the conspicuous pattern is of advantage in attracting her attention or in distracting the attention of enemies from the nest on which she is sitting.

Conspicuous patches of colour, like sounds and scents, may

be useful as recognition marks, especially amongst gregarious animals, or where the young follow the mother. Notable instances are the yellow or white patches on the rumps of many deer and antelopes, which stand out conspicuously against the general brown coloration of the body; whilst the white, erect tails of rabbits and other small creatures that run in single file in the dusk along special tracks may well serve as moving sign-posts.

The most common case of the utility of conspicuous coloration is when that serves to advertise an animal to its enemies, so that it may be easily seen, easily remembered and avoided in future. It is plain that such an advertisement is of little use unless it be associated with the existence of an unpleasant or dangerous property, such as nasty flavour, bad odour, power of stinging or of giving poisonous bites. The advantage is either to the individual animal or to the species, or to both. It is useless for a snake to have to strike its poison-fangs into an animal that is too big for it to eat; it is worse than useless, for the process exhausts the poison glands temporarily and puts them out of action so that they cannot be used for some time for the purposes of the snake, whilst there is always a chance of the snake itself being killed and eaten by its prey. And so bright colours, terrifying attitudes and noises, such as hissing and rattling, are useful to the snake. Warning colours are still more useful in the case of bees where the sting is left in the wound and its loss kills the bee. Very many small animals with evil odours, such as skunks, have patterns of vivid black and white which are specially visible in the dusk, and it is supposed that they can thus be recognised by carnivorous animals that otherwise would kill them and then find themselves unable to eat them. No doubt a few individuals would perish each season whilst young carnivores were learning the lesson that such animals were not worth the trouble of killing, but the species would gain.

Opinions differ widely as to the closeness of relation between unpalatability and bright colours amongst insects, but after reading through a considerable part of the very extensive and rather pugnacious literature on the subject, I think there is a strong balance of evidence in favour of the

view first suggested by A. R. Wallace to Darwin, that adult insects and caterpillars which insectivorous birds and lizards find nauseous are extremely often brightly coloured and conspicuously marked. Some of the most striking negative experiments have been made on birds and reptiles in captivity, and as these are frequently tame and accustomed to take any food that is offered to them, it is not surprising that they have been found to eat insects that are probably nauseous. Such negative evidence is more than outweighed by the cases where they have either completely refused the subjects of experiment or rejected them after tasting; whilst the fact that brightly coloured insects and caterpillars in their native haunts very seldom conceal themselves is a cogent argument for a view that they are unpalatable. It has been found, moreover, that young birds—and no doubt the same is true of young lizards—have no instinctive knowledge of which insects are not good to eat, and that they have to learn by experiment. Such experimental tasting must be disastrous to the individual subjected to it, but as insects and their caterpillars usually occur in great numbers at a time, the species gains, although some of its individual members perish.

Other cases of the possible utility of bright colour and conspicuous pattern are grouped under the theory of mimicry. It is certainly true that some animals without unpleasant qualities resemble very closely, in their appearance and ostentatious habits, other animals living in the same locality which have both conspicuous coloration and some quality the possession of which it is useful to advertise. The genuinely unpleasant creature is called the model, and the creature resembling it is called the mimic, and it was supposed by H. W. Bates, who first suggested this explanation, that the imitation of the model by the mimic was useful to the latter by deceiving its enemies into the belief that they had to deal with an animal better left alone. The most probable examples occur amongst insects. Ants, because of their ferocity and their power of defence and aggression by means of their biting jaws and venomous stings, are very generally left alone by other members of the animal kingdom, and are frequently closely imitated by harmless beetles and bugs. The stinging bees

and wasps are similarly imitated in coloration and pattern by harmless flies. Many tropical butterflies and moths that are known to be distasteful are brightly coloured and show by their habits and slow flight that it is not necessary for them to avoid attracting attention. They are closely mimicked by other butterflies and moths that are not distasteful.

The theory of warning coloration and the associated theories of mimicry have been attacked partly on the ground that there is not enough experimental evidence to justify them, and partly on the ground that the pattern and colour can be explained otherwise. On the whole there seems to be enough experimental evidence to justify the conclusion that there is a frequent association between conspicuous coloration and unpleasant qualities on the part of the models. It is, however, another matter to assume that the coloration of the models or mimics has come into existence because of its utility. The colours and patterns may be the natural outcrop of the constitutions and modes of growth of the creatures in which they are found; and if this be so, if in fact they belong to what I have described as the lowest grade of ornamentation, it is not surprising that they should occur in closely similar forms in closely allied species.

There is no quality more generally useful to an animal than that of being inconspicuous. The living world is a very serious game of hide-and-seek, in which nearly every adult animal and those young ones that are not hidden or protected by their parents must join. The penalties are severe; those that are caught are eaten, and those that fail to catch starve. Animals may hunt their prey by scent, but there nearly always comes a critical final moment, when they must be able to see the object on which they are to pounce. Animals may escape by swiftness, but it is extremely useful if they are so invisible that their enemy cannot easily follow them by sight, and still more useful if when they are hard pressed. or when they have reached a favourable spot, they can suddenly fade into the background and become invisible.

There is no arrangement of shading so common in the animal kingdom as for the upper surface to be darker than the lower surface. Even in domestic animals we are accus-

tomed to see the under parts light or white in comparison with the back. But in wild nature the dark shading of the upper surface and the lightening of the lower surface seem to be almost the rule. The contrast is visible even in the tawny lion and the striped tiger; jaguars, leopards and most of the smaller cats, however they may be spotted or striped, show it. It is conspicuous in zebras, wild asses, deer, sheep and goats and antelopes, in hares and rabbits, in kangaroos, in whales and porpoises, in an enormous number of birds, in snakes and lizards, in frogs and toads, in very many fish, whilst most of the creeping insects and their larvæ exhibit it. There is no obvious difference in the structure of the body to account for it; the skin, fur, feathers or scales are formed in the same way from similar materials all over the body, and the difference cannot be explained as the visible expression of anatomical facts. Nor can it be explained as being due to the direct action of sunlight, for the most probable effect of intenser sunlight on tissues is to bleach rather than to stain, and if there be a difference according to habitat, the contrast is greater in many of the swarthy inhabitants of forests than in natives of the open plains.

The natural disposition of light and dark colour on an animal is so arranged as to counteract the result of natural illumination, for the dark shades are found on the upper parts where the illumination is greatest, and the light shades on the under surface where the illumination is least. The natural pattern, in fact, is a counter-shading of the natural illumination. In this way the plump solidarity of the natural contours of an animal fades into a ghostly elusiveness against its natural background, especially when the light is rather diffused, as on a cloudy day, or where a creature is lurking in a shadowy corner for its prey, or tips and fades into a covert when it is being pursued. A model often exhibited in museums shows the real invisibility conferred by counter-shading. Two bird-shaped bodies are fixed on a rod that can be revolved, and are placed in a case with a glass roof lighted from above, with the side next the spectator open and the background and two other sides painted with neutral grey. The body of one bird is painted all over as nearly as possible

the same shade as the background; the body of the other is darkened above and made lighter than the background below. At a little distance, the self-tinted model stands out clearly from the background as the solid body of a bird, white above where it is illuminated, dark below where it is in shadow; but the other model is almost invisible, for the counter-shading neutralises the effect of the illumination. If the rod on which the models are fixed be rotated, the neutrally tinted body remains visible, whilst the counter-shaded model, as its shading is now disposed so as to agree with the natural lighting, becomes visible at once, being even more conspicuous than the other.

Counter-shading is a character that may be found in various degrees of strength combined with many different kinds of coloration and pattern, the utility of which may be set down generally as ways of matching the environment. In most of the desert animals the various shades of sandy brown known as "khaki" are the prevailing tints. In insects that live on green foliage, the ground colour is frequently a shade of green. In ground-haunting birds like snipe and woodcock, which live among fallen leaves and sticks or in weeds and grasses, the surface is blotched, striped and mottled in irregular lines and patches, which resemble the usual background, and which, with the addition of counter-shading, make an almost perfect concealment. Especially in the plumage worn during the nesting season by the females, the surface may present a very elaborate picture of the leaves, sticks and stones, mossy trunks, heather and so forth among which the females have to brood on their nests, and if possible remain unnoticed by their carnivorous foes, so that they may preserve their own lives and those of their helpless young. The spotted coats of leopards and jaguars, and of many deer, similarly match the natural background of light shining through the interstices of foliage; whilst the stripes of the tiger and of many of the antelopes suggest the effects of light and shade thrown by tall reeds and thick grass.

The various forms of matching the background with which I have been dealing are most successful when the wearers of these liveries are at rest, and their utility is plainest in the case

of animals which have the habit of squatting on the ground, whether to await their prey or to avoid their enemies. Familiar examples are the brooding female bird, the hare squatting in its form on the open ground, or the tiger crouching to spring. Another and more interesting kind of protective coloration is most useful to males displaying themselves

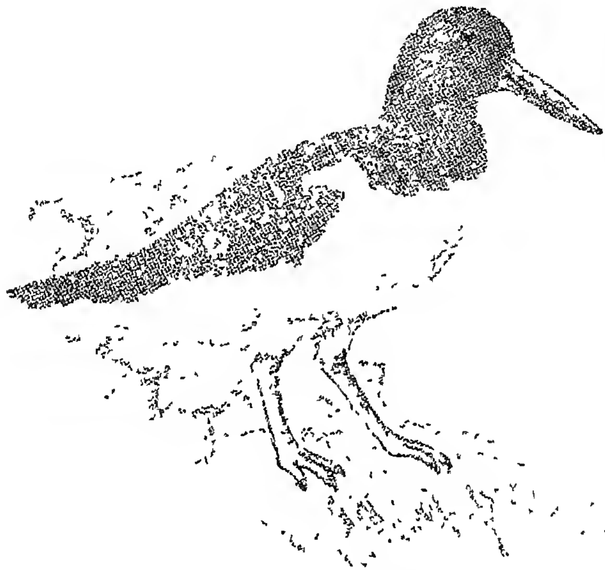


FIG. 20. Oyster-catcher, showing counter-shading and ruptive pattern.

before the females and with their attention so engrossed that they are not on the watch for their enemies, or to creatures in active motion in pursuit of prey or in search of food. Such moving creatures come under different effects of light and shadow, are now lighted up by the sun, now suddenly brought against a light background or a dark background, and are under conditions where any elaborate matching of details would be useless. Some of the boldest patterns and brightest

colours, combinations that seem amazingly conspicuous in a cabinet or a museum, really serve for concealment under the natural conditions. They break up the natural outline of the animal, which would be otherwise conspicuous by the uniformity of its shape against the irregularity of its surroundings. The great white patches on the hindquarters of many deer and antelopes, which are sometimes expanded when the creatures are excited, break up their outline when seen from behind. The black-and-white markings on the head and face and the curious reversed coloration of small carnivores like badgers and skunks and ratels make them more conspicuous to us, but when seen against the sky-line at dusk by the small prey which they hunt, serve to make them invisible. The vivid black-and-white patches of many shore birds (Fig. 20), the curious appendages, the secant lines across the body, the odd markings of the head so common in birds, serve a similar purpose. The strangest and most violent patches of colour, the bright plumes, and the shifting iridescences, all may help to dazzle the eye of victim or enemy.

As I have already said, it is necessary to be careful to distinguish between the possible usefulness of coloration and the causes which have brought it into existence. But I think it is plain that as we pass from the patterns that are the fairly obvious result of growth-forces, such as the simple geometrical markings which are visibly structural, through the more irregular stripes and blotches which may be set down to irregular growth, to counter-shadings and elaborate background-matching, and still more to odd and brilliant disguises of the true contours of the body, we come into regions where we may more and more expect that the results have been shaped and controlled by a process of natural selection and serve some purpose of direct utility to their possessors.

CHAPTER VI

COLOURS AND PATTERNS OF YOUNG MAMMALS

THE difference in coloration between young mammals and their parents often depends simply on immaturity. The skin may be smooth and soft, the scanty hair silky in texture, and the general coloration pale, merely because the young animals are not yet fully developed, because their structure is incomplete and the physiological processes which produce pigment are feeble and ineffective. The little creatures, in fact, may remain partly embryonic after they are born, and differences due to this belated development are especially plain in those species where the young are feeble and most dependent on their parents. The first liveries acquired by such animals, as well as the liveries of those that come into the world active and furry, often differ in a remarkable way from the full dress of the adults. If the adults are spotted, the young are always spotted; if the adults are striped, the young are either striped or spotted; even if the adults are self-coloured, or have acquired one of the striking patterns of the higher grades that not only do not conform with the architectural lines of the body but serve to disguise or interrupt these, then the young may still be striped or spotted.

The possibility of changing the pattern and colour of the exterior of the body comes about in mammals and birds because these for other reasons are able to moult. Animals have to contend not only with the larger kinds of foes which are able to pounce on them, kill them and devour them bodily, but with a multitude of minute enemies which harbour on the outside of their bodies and injure their health in many ways. The spores of bacteria and moulds are rained on them from the dust of the air, are rubbed on them by contact, or are floated on them in water. Fleas and bugs, lice and ticks, a prolific swarm of hungry vermin, provided with biting and sucking organs, grasping hooks, claws with adhesive pads and

devices innumerable for maintaining their position if once they reach the body, assail them. These parasites may do much or little direct harm; sometimes they feed only on the waste secretions of the body and do little more than cause a tickling irritation; sometimes they burrow deeply, or scratch and gnaw until they produce serious wounds, or weaken their host from direct loss of blood. Still more often those that are blood-suckers do damage, not only directly, but by introducing the seeds of diseases that may be fatal, carrying them from infected to healthy animals. Many of the soft-skinned lower animals, such as newts and frogs, and still more worms and slugs, whose bodies would otherwise be a ready prey, are protected from the attacks of external parasites by their power of producing slimy secretions which float off the intruders before these have time to establish themselves. Other animals keep their skins clean by a process acting like the scaling paints with which the submerged parts of warships are covered, to prevent their bottoms getting fouled with barnacles. The outer horny layer of the skin is constantly shed off, carrying with it many of the parasites and leaving the surface clean. Sometimes this process is slow and continuous, as in ourselves, sometimes it takes place at regular intervals, in large sheets which may extend to the whole body, as when a serpent sloughs, casting off the complete outer layer of the skin, even to the transparent membrane of the eye.

The warm coats of fur or feathers which protect the bodies of most mammals and birds are formed chiefly of the outer horny layers of the skin, and, within certain limits, can be cast off and renewed. This process of moulting is useful in many ways. It gives the opportunity of replacing coats that have become worn and faded, by coats that are bright and clean. It gives the opportunity for a change of clothing from the warm covering necessary in winter to the lighter covering which is more healthy in warm weather, and perhaps most important of all, it makes possible periodical changes in colour and pattern. Just as when the outer layers of the skin are shed off they may be replaced by differently coloured layers, so the old hairs or feathers, when they fall off, may be replaced by hairs and feathers with different colours and

patterns. It is the process of moulting far more than any actual change in skin, fur or feathers that underlies the differences between young and old animals, or between mature animals at different seasons of the year.

Lemurs, monkeys and human beings form the most highly modified group of mammals, the group that is farthest removed from the reptilian ancestors, and I do not know of any in which either the young or the adults are spotted or striped, except that the tails are sometimes ringed. Like human beings, young monkeys are born with a very scanty coat of silky hair, large parts of the body being naked. The face, hands and feet are usually black in monkeys, but just as the hands or feet of negro infants are paler in colour, so these regions in very young monkeys are white or pink. A complete coat of fur appears in a few months, and if there be no difference between the sexes, it is like that of the adult from the first, but paler. The face and hands acquire the pigmentation more slowly, and if there are brightly coloured patches of naked skin, these are the last to appear and do not acquire their full richness until the animal is almost adult.

The Cats, great and small, show abundant traces of a primitive spotted pattern. The spots are most frequent in the young. The whole group shows extremely well the replacement of the primitive growth pattern by patterns of higher grade. The changes in coloration are produced either by a gradual loss and replacement of the individual hairs—and this usually takes place in the natives of tropical countries—or by a regular moult at the beginning of the warm season and a slighter moult with a rapid growth of thick fur at the beginning of the cold season. The winter coat is often lighter in colour because of the growth of a very thick under-fur.

The young are always born with a thick and soft coat of fur. In the tiger and the striped cats and in all the spotted cats, the coloration of this differs from that of the adult only in being rather paler, whilst in those cats which are brown in the adult condition the young are profusely spotted. Young lions are thickly set with spots, especially on the sides and under parts, whilst the tail shows signs of dark rings. Although pumas are nearly uniformly coloured, tawny-brown

in winter and redder brown in spring, their cubs are vividly marked with black, stripes and spots on the face, a broad band on each side of the face, spots on the legs and under parts and rings on the tail. Caracals, until they shed their puppy coat when they are about six months old, are very brightly spotted on the under surface, whilst lynxes, which are greyish-brown in their adult summer coats, are profusely spotted with black when they are young.

The young of these cats are so carefully hidden, and so zealously guarded by the mother—who is more ferocious in defence of her cubs than the females of other species—that they have little need of the protection that concealment might give. I do not doubt but that a spotted coat serves as a protection, partly by breaking up the outline, and still more in the case of those animals that live in the forest and crouch for their prey at the edges of open glades, or lie along the branches of trees where their marks would blend with the dappled disks of light and patches of shadow formed as the sunlight filters through the foliage. It is more than probable that the spotting of adult jaguars and leopards, servals and cheetahs, and the various spots, stripes and blotches of the smaller cats are the patterns of the young, retained and made more vivid by natural selection. It is usual to see a relation between the vertical shadows thrown by reeds and tall grasses and the striping of the tiger, and it is a fair supposition that the coat of that splendid cat is still further modification of a primitively spotted livery. The self colour of lions, pumas, caracals and lynxes has unquestionably come about by the obliteration of the spots found in the young, and in adult life traces of spots remain in varying degrees, but most strongly on the under surface and on the legs where they are least conspicuous. It seems certain that the spotted skin of young cats, like that of many other animals to which we shall come later, is a natural growth pattern which is retained in adult life where it is useful, or accentuated by transformation into stripes, or obliterated to a self colour.

The small carnivores, such as civets, genets and linsangs, binturongs, ichneumons and mungooses, show a similar general set of patterns. In almost any group, some are

spotted, others are striped, whilst in a few of the adults the coloration is nearly uniform except for the usual counter-shading, and it is not difficult to see a general relationship between the kind of coloration and the nature of the ground in which the animals are habitually found.

In hyænas, wolves, dogs and foxes, there is seldom much difference in pattern between the young and the adults, although the fur is shorter and usually thicker, and spots are common on the under parts. Some of the jackals have distinctive liveries, and in these the cubs are more simply coloured. The canine animals vary a good deal in their mode of moulting, but the northern forms have a fairly definite autumn and spring moult. Arctic foxes, for instance, which are white in winter, shed the greater part of the summer coat in a few weeks, replacing it gradually by the thick white winter coat; whilst in early summer or spring of the following year they again shed the winter coat and replace it by the thinner, dark summer pelage.

Young bears are extremely like the adults, and the puppy coat appears to be retained as the first winter coat. The tropical bears, such as the Himalayan, sloth and sun bears, change the hairs singly, and have no thick under-fur. The polar bear sheds the thick under-fur and a considerable portion of the whole coat in the water rather early in spring, at least in the case of bears in captivity; in autumn much of the coat is shed singly hair by hair, but the chief change is the growth of a thick under-fur. The brown bears and grizzlies moult off the thick winter fur in masses early in spring. With bears, like most of the wolves, dogs, foxes and jackals, there is no striking difference between the patterns of the young and the adults.

The many families of small carnivores, such as raccoons, pandas, coatis, martens, polecats, weasels, gluttons and skunks, ratels, badgers and otters, have generally brilliantly marked fur, with ringed tails, striped bodies, or conspicuous marks on the head or body; nearly all of them have an autumn and a spring moult, and there are many cases where the pelage of summer and winter is notably different, in colour as well as in quality. The young are born in holes or nests, usually

in an imperfect condition, nearly always blind, and sometimes naked, as in the polecats and mink. Even if they are born with fur, the first coat is fine and silky, very often white in colour, and this towards the end of the autumn is gradually replaced by a rough puppy coat which persists until the spring moult. It is possible that the light colour of the first coat may make the animals more visible to the mother in the dark holes or nests where they are born. They are born in an immature condition partly because the mothers have to catch their prey by agility and would have difficulty in obtaining a living when heavy with young.

The seals are probably terrestrial carnivores which have taken to living in the water, although they come ashore to breed. The young are born covered with hair and in a well-developed condition. The young of the eared seals, which include the fur seals, sea-lions and sea-bears, are able to swim in an hour or two after their birth, and the first coat is thick but silky and in almost every case very much darker than the pelage of the adults. The young of the true seals, which have no external ears and in which the hind-legs are turned backwards and dragged after the body on land, instead of being used for progression, show a curious reluctance to take to the water, and may spend weeks on shore. They are born with a white and silky coat which is shed very quickly, and replaced by a longer and more woolly puppy coat.

The young of all the ruminating Ungulate animals are born in an advanced condition, and it is by far the most usual case for the pelage to differ little from that of the adult, except in the absence of specially marked manes and beards. All those that live in cold countries assume a thick winter coat which they shed in spring, and the pattern of this coat may be a little different, whilst its hairs are longer, more closely set and rather woolly. The young animal begins to assume the appearance of the adult in the spring after its first winter but usually moults once, a few weeks after it is born, replacing a sparse puppy coat of rather long and silky hair by a thicker coat.

Amongst cattle there is little difference between young and adults, but the coat of the young is usually lighter and redder,

and where the adult has a strongly contrasting pattern of black above with white under parts and white "stockings," this is less conspicuous in the young, suggesting that the adult pelage is a later acquisition.

The great family of antelopes show many conspicuous colour patterns, and differences between the young and the adult are frequent. The hartebeestes, bontebok and gnus live for the most part in open plains, and except for counter-shading are usually self-coloured in some yellow, brown or

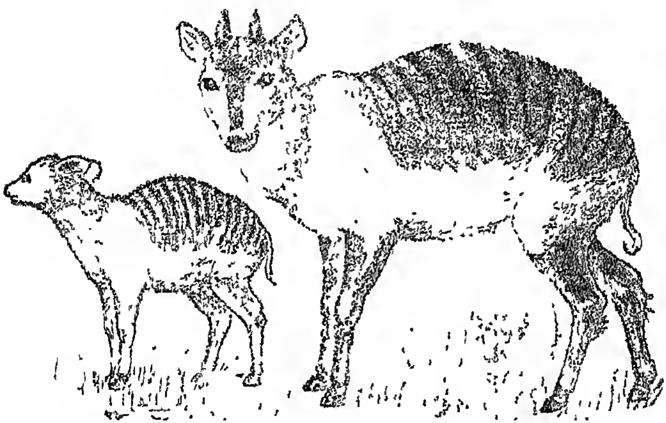


FIG. 21. Young and Adult Banded Duiker Antelope. (*After* JENTINCK.)

reddish shade, with various bands or blotches of black and white, such as round the upper parts of the legs, on the face or on the rump, which certainly have a ruptive effect—that is to say, they break up the natural outline and obscure the contours, when seen from a distance. The calves are much more uniformly tinted, suggesting that, as in the cattle, the conspicuous patterns of the adult are later acquisitions. The duikers, a family of antelopes with very small horns, which haunt long grass and brushwood, have a coloration ranging from pale mouse-colour to bright bay, whilst many

of them have broad dorsal bands or saddles of black or white or yellow, and various face and head marks which have a secant, outline-interrupting effect, and in these the young show the conspicuous pattern of the adult in a very faintly marked fashion, if at all. There is one striking exception, however. The banded or zebra duiker of Liberia

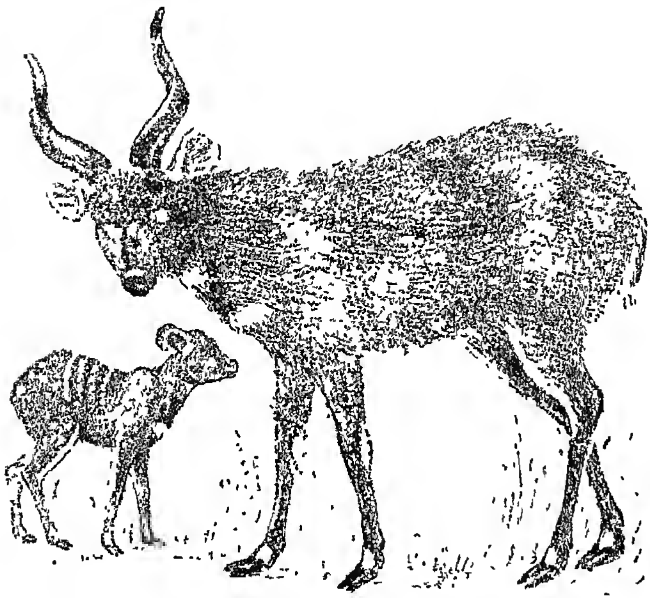


FIG. 22. Young and Adult Selous' Sitatunga Antelope (*Partly after* SCLATER *and* THOMAS.)

(Fig. 21) has the tawny back marked with bands of black arranged like the hoops of a barrel, and this pattern is practically alike in the male, female and young. The klipspringer, oribis, dik-diks and the reed bucks, water-bucks and kobs are seldom brightly patterned, and the young are very much like the adults. In the very large family of gazelles the patterns

are seldom conspicuous; the general coloration is a shade of fawn, lighter below, frequently much darkened on the back, especially in old males, whilst face markings, rump patches and lateral stripes are frequent. Where the young differ from the adult, they are almost invariably more uniformly coloured.

The young Selous' sitatunga antelope (Fig. 22) has a livery of reddish-brown with spots on the flanks, and rows of spots just fusing into barrel hoops across the back; but these have faded out almost completely in the adult female, and completely in the adult male, which is dark brown. In Speke's sitatunga and the Congo sitatunga, the contrast between adult males and females is not so great; slight traces of the stripes are retained in the male, rather more in the female, whilst the young is as richly marked as the young Selous' sitatunga.

In antelopes generally there is to be noticed the same general tendency that occurs amongst the carnivores. When the young differ in pelage from the adults, they resemble the females more closely than the males; they show far less trace of special ruptive and secant patterns, of those patterns which follow the primitive contours of the body least, and show frequent traces of spots and stripes, and similar simple growth patterns.

The prongbuck or American antelope, which lives in upland prairies and on rocky slopes where the snow lies in patches until late in spring, and descends again in early autumn, is one of the most striking examples of ruptive pattern. The back is rich tan with black on the head, and great disks of white on the rump, whilst the face and sides have patches and areas of white sharply marked off from the darker regions. The females have similar but less brightly marked patterns, whilst the young are almost uniformly clad in pale greyish-brown with only the faintest trace of the adult coloration. Here is another instance of one of the highly specialised patterns which cannot be easily associated with the natural structure of the body, appearing only with adult life.

The well-known pattern of the Giraffes suggests in a vivid way the origin of colour pattern from the tessellated or particulate character of the skin. It consists of a series of spots or blotches which grow darker with age, placed on a

pale background, and in some species leaving only a narrow reticulation of the pale ground between the spots. The young, as soon as they are born, show the spots clearly marked. Many hunters have borne witness to the fashion in which this apparently vivid pattern makes the animal almost invisible as it stands under the trees on which it feeds, and it appears as if the pattern were a simple growth form that had been retained because it was either positively useful or at least harmless.

Deer show a most interesting set of differences in the relations between the young and adult patterns. The young, in by far the greater number of species, are spotted, and although it must certainly be the case that this pattern helps to conceal a fawn lying quietly in the shadow of trees, the presence of spots is so common, whether the deer inhabit woodland or not, that it seems more natural to think of it as a primitive growth character such as is found in many other groups. In some deer the spots are retained throughout life. But in a very large number of deer belonging to different groups and with very different haunts and habits, the spotted coat of the fawn is shed in a few months, and although there may be regular changes from summer to winter and from winter to summer pelage the spots never again reappear. This happens with the common red deer and wapiti and their allies all round Europe, Asia and North America, with Eld's deer, roe-deer, the Chinese water-deer, the curious little brocket deer of America, the Virginian deer, the mule-deer and the very peculiar musk-deer. Finally, there are a few deer belonging to different groups in which there is no trace of spots in the young or the adult. Amongst these are the Sambur deer, except the Philippine Islands form, the muntjacs, reindeer, elk and the American guemals and pampas deer. It is at least interesting to notice that spots tend to disappear in winter coats and in the northern races of deer, and that they are retained in deer which are not nocturnal.

The pig-like little chevrotains or mouse-deer come very close to the ruminants, but do not actually ruminate, and in many ways are intermediate between deer and pigs, certainly representing a very primitive type of animal that has sur-

vived. In the Indian chevrotain and the African water chevrotain, the bodies of the young and adults are alike, reddish-brown, and much spotted with white, the spots being often joined to form bands. In the adults of two other species found in the Malay archipelago the coloration is more uniform, darker above and lighter below; the smaller one shows traces of faint lines recalling those of other chevrotains, and these are more strongly marked in the younger animals. I have been unable to find any account of the pattern of the very young individuals, but it is highly probable that it is spotted or striped.

In the Bactrian camel, the dromedary, and in their American allies, the wild vicugna and huanaco, and the domesticated llama and alpaca, the young are rather paler and more uniformly coloured than the adults, but resemble them very closely.

If we turn now to the non-ruminant, cloven-footed Ungulates, we find some more cases of differences between the young and the adults which are not readily explained as direct adaptations for protection. In all the true wild swine the young are paler and pinker than the adults, in which there is almost always much dark brown and black. The little pigs are pale or reddish-brown; and are marked with longitudinal rows of stripes, rather faint and irregular, and partly broken into spots. So also the young of the pigmy hog, the river-hogs and the wart-hogs are striped. Certainly these animals haunt ground where a striped pattern might aid in making them less visible, but the stripes are faint, and not sufficiently clearly marked on the ground colour to have much effect, whilst the parents guard their young with so great devotion and with so powerful weapons that the little pigs have no need of concealment. It is much more probable that this is another example of natural growth pattern.

The hippopotamus is self-coloured; and its young differ from it only in being much paler and pinker.

Among the Odd-toed Ungulates, the tapirs, rhinoceroses and horses, it is only the tapirs that present a striking case of difference in pattern between young and adults. The full-grown American tapirs are nearly uniformly coloured, dark

grey-brown or black above, a little lighter below, but with a white line round the edge of the shell of the ear. The Malay tapir has the head, forequarters and legs very dark brown to black, but the whole of the hinder part of the body above and below is white and there is the same rim of white round the ears. There is no difference in the coloration of the sexes. The dull coloration of the American animal, with its counter-shading, may well suit the muddy edges of the rivers and lakes and marshes it inhabits, whilst the black and white of the Malay species is a good example of ruptive pattern, and when the animal is lying amongst the boulders at the edge of a river in the tropical sunlight, is said to be extremely difficult to see. But the young tapirs, both in America and Asia, follow their parents closely, and share their surroundings, and yet are amongst the most vividly patterned of living animals. Their dark bodies are profusely striped and spotted with white, the stripes and the rows of spots being arranged longitudinally like those of young pigs, and being extremely alike in all the species. I think that it cannot be doubted but that this infantile pattern (which is lost in a few months) is a natural growth pattern. Its similarity in American and Malay forms, which are so unlike as adults, points to such an explanation being correct.

In the several species of rhinoceros the coloration is nearly uniform, and the young differ very little from the adults, except that they are more hairy and paler.

Except that foals are rather more lightly coloured than adults and frequently have a continuous mane of short erect hair running along the middle line of the back, young horses, asses and zebras differ very little from their parents in coloration and pattern. Spots, dapplings and stripes are extremely common; if they are present in the adults, they are always present in the foals, and not infrequently traces of them occur in foals and fade out when the colouring of the adult has been reached. It is difficult to resist the conclusion that a striped pattern is primitive in the group and represents a natural growth pattern which is in course of obliteration.

The conies or hyraxes resemble their parents in coloration very closely, but are generally rather darker, and the young

of different species are more alike than the adults.

Young elephants are lighter in colour and much more hairy than the adults.

Nearly all the Rodents are quietly coloured creatures with little or no difference in pattern between the males and females. They are the prey of many enemies and have little powers of defence. They are disposed to avoid daylight, coming out just before dusk and again in the very early morning about dawn. Their subdued hues suit their habits. They are usually self-coloured with more or less of counter-shading. A few are striped or spotted, the stripes or rows of spots always being arranged along the length of the animal. Some of them, however, and particularly the squirrels, are vividly coloured, the colours being in great masses or patches. There are usually two moults in the year, the winter pelage being duller and less brightly patterned, whilst the vivid colours are assumed for the breeding season. The young are often born in underground nests, in hollow trees, or in other dark and well-concealed places, and those that are produced in such nurseries are very immature, naked and blind. On the other hand, if, as in the hare, the young are born in the open fields, and have to run the danger of being discovered by enemies, they come into the world in a more mature condition, able to see, and clad with fur. When the first coat of fur has been gained, it is striped like that of the adult, in the striped forms; in others it is a paler imitation of the adult pattern.

The Marsupials are still more quietly coloured than rodents, a certain amount of counter-shading being the chief variation in the general clothing of dark grey or brownish fur, but a few like the spotted dasyures and the striped Tasmanian wolf have special patterns. The sexes are always alike, and the young, which are born as naked and quite immature embryos, acquire the pattern of the parents as soon as they become clothed with fur.

If we consider the patterns of mammals as a whole, it is plain that the simplest and most primitive types consisted of spots, and that these were the expression of the tessellated or particulate character of the skin. In the natural course of

growth these spots may expand into short stripes, or they may fuse to form bands running hoopwise across the body, or along its length. If there is a pattern of this kind in the adult, it is always present in the young. Undoubtedly it must often aid in making the young animals or the adults invisible as they lie in the dappled shadow of leaves, but the pattern occurs so often, in so many different kinds of animals, living under so different conditions, that although it may have been retained because it was useful, it does not seem probable that its usefulness is the direct cause of its origin. Very often the primitive spots or stripes are replaced in the adult by an even tone, marked only by counter-shading, and sometimes this monotonous tint appears even in the first coats of the young. The fact that it so often replaces a primitive livery of spots would seem to show that it is of later origin, a more highly developed kind of pattern. Lastly, it very frequently happens that instead of a monotonous shade, the body is marked by vivid patches of light and shade, or of colour, over regions that do not seem to correspond with structural differences of the body. These showy, conspicuous patterns are often ruptive, and may serve for concealment by breaking up the natural outlines of the animals. When they are present, they are generally more strongly marked in the males than in the females, and they replace either the monotonous or spotted or striped pattern of the young.

The changes from juvenile to adult patterns are frequently abrupt and are associated with the natural autumn or spring moult. When the young animals become nearly full grown in one season, they appear first in the rough and plainer winter pelage; when their youth lasts longer, it is not until the moult after the first winter that they assume the pattern of the adult.

CHAPTER VII

COLOURS AND PATTERNS OF YOUNG BIRDS

THE complicated changes in the outer coverings of mammals enable us to understand the still more complicated changes in birds. Primitive mammals appear to have been spotted or striped, marked with patterns that were the expression of the nature of their skin, and of the natural processes of growth. These simple patterns were replaced by patterns of a higher grade, first by a process merely of obliterating them, then by changing them still further by the development of counter-shading, of secant and ruptive marks that disguised the natural shape, and of various exuberances of ornamentation. In a very large number of cases the primitive growth patterns are repeated in the young; sometimes these have disappeared even from the young, which start life in a garb of the second grade, and acquire as they become adult, and especially if they are males, the highest and most specialised kinds of coloration.

Feathers are even more important to birds than fur is to mammals. Their arrangement, colour and patterns make up the greater part of the appearance that a bird presents to the world, to its friends or to its enemies; the body of a plucked bird has lost the characteristic size, shape and appearance to an extent that is almost grotesque. The down and contour feathers retain the internal heat of the living body, a necessary protection as the blood of birds is hotter than that of mammals and as their physiological processes are more active. The quills of the wings and tail form the light and strong expanses which are used in flight. A feather is a more elaborate organ than a hair, and there are many kinds of feathers, several kinds of plumage and a very elaborate system of moulting.

The most characteristic feathers are the large quills which lie in a single row along the outer edge of the joints of

each wing and are disposed fanwise on the tail. These are found in all birds; their quite obvious presence in the flightless ostrich shows that that bird and its allies have lost a power of flight which they once possessed, and they can be identified even in penguins. Brush turkeys are the only birds in which they are so fully formed at the time of hatching that they can be used for flight at once, but they appear very quickly in all young birds and can often be counted long before the chicks have left the egg. Quills are usually replaced once a year. Some water-fowl shed them all at once, and in their unhappy flightless period have to hide in the reeds in some sheltered corner of a lake, an easy prey to any foe that discovers them in their day of peril. In most birds they are shed and replaced in pairs, so that at any time there are not more than one pair in the wings and one pair in the tail out of action, and there are always enough for flight to take place.

Besides the quills, there are two kinds of feathers, more or less corresponding with the fur and the under-fur of mammals. There are the contour feathers which make up the greater part of the covering of the body, giving that not only its shape but most of its colour and pattern, and forming the decorative plumes on head and wings and tail. They are not spread evenly over the surface of the body, but are inserted on special regions, with naked spaces between them in all except a very few birds, and even in some of these, such as the ostrich, they are arranged on definite tracts in the young bird, although they are evenly distributed in the adult. Secondly, there are the softer, more tuft-like down feathers, corresponding with the under-fur of mammals, and like that found most abundantly in creatures which require special protection from cold. These may be attached to the interspaces between the contour feathers, or they may be distributed all over the bird, or they may be found only on the feather-tracts, concealed by the other feathers. It seems most probable that these down feathers are a later development and are degenerate contour feathers, the only purpose of which is to thicken the warm covering of the body.

There are many reasons why birds should moult, and from

time to time renew their outer garment, which is at once an ornament, a protection and a most useful organ. Feathers are fragile and quickly become frayed, broken or worn. Sooner or later, if the plumage is to retain its usefulness or to alter its appearance, it must be changed by a moult.

The moults are sometimes associated with changes of colour and pattern, and sometimes merely lead to the restoration of the discarded dress in a fresh condition. Most birds are brilliant for a part of the year, sometimes only for a few weeks of courtship, sometimes for the greater part of the year, and sometimes for the whole year round. The different plumages that birds may assume successively as the results of moults are so varied that it is not easy to get a clear picture of them.

First of all, the chicks may be clad in a coating of down. This may be replaced by one or more successive immature plumages and these may be followed by different kinds of adult plumages. The adult plumage may be the same all the year round, and in that case the males and females may be alike or different. There may be a specially brilliant plumage assumed in the breeding season, by the males only, or by both males and females. When the breeding season is over, the brilliant plumage may be lost, the birds passing into what is now known as "eclipse" plumage, and this may be identical or different in the males and females. Some examples will make the matter clear. In winter, the common lapwing or peewit is a dull-coloured bird, with a very short crest, a brownish head, a white or grey neck, and with the black mottled with dark brown. The males and females differ very little. In early spring a moult takes place. The male becomes resplendent, with a long crest, and a body shining with metallic olive-greens and purples, steely-blue and ruddy-brown, picked out with vivid black and white. The female is a less brilliant copy of the male, with a shorter crest and a dimmer lustre. When the breeding season is over, there is a second moult and both sexes appear in the winter garment of repentance. In this case the "eclipse" plumage coincides with winter, and the breeding plumage with summer. The next example I shall take is that of a very different kind of bird. The

beautiful little passerine bird known as the superb tanager, and often seen in zoological gardens, is a jewel of colour, shining with green, orange and shades of purple and blue, the female being only less brilliant than the male. These resplendent garbs are the breeding plumage and are retained for rather more than half the year. There is then a moult, and both males and females pass into a dull brown eclipse plumage in which it is very difficult to distinguish them. The contrast is not always so great as in the two cases I have taken, and it is more common for the female to remain comparatively dull even after moulting into the breeding plumage. Nor is the division of the year between the two plumages usually so regular. A dull eclipse livery for both sexes for the greater part of the year, with a bright breeding dress at least for the male for a smaller part of the year, is the most common state of affairs.

No set of birds display more brilliant patterns and fantastic decorations than are to be found amongst ducks, where, however, the drakes are bright whilst the females show little colour change. This gay plumage is found in the breeding season in its most brilliant form, but, unlike the lapwings, drakes may retain it for the greater part of the year. Lastly, there are a number of birds, such as parrots and kingfishers, in which there is no change throughout the year, but the most brilliant colours are retained permanently, and when the single annual moult occurs an identical livery is assumed. In these birds the males and females are both brilliantly coloured, usually alike, although there is the odd case of the Eclectus parrots, where one sex is green, the other scarlet.

When birds are hatched, some, like ducklings and chickens, are born with a warm coating of down feathers, and are able to run about, see and peck almost as soon as their coats are dry. Others, such as the chicks of most of the familiar singing birds, come into the world helpless, blind and naked, entirely dependent on the care of their parents. If the eggs are laid in safe, inaccessible places, as in nests on trees, or in holes, the young are usually helpless. If they are laid where the young chicks may have to take refuge in the water, or to hide in the herbage at any moment, they are hatched only when

the chicks are able to swim or to run about. When the young are born in a precocious condition, the eggs are larger in proportion to the size of the parents and take longer to incubate. The average time of incubation is from eighteen to twenty-six days; humming-birds, which lay small eggs even in proportion to their small size, brood over them for less than a fortnight, and the newly hatched young are naked and helpless. Ostriches and their allies lay eggs which are very large even in proportion to the large size of the parents, and when the chicks come out they are able to run about almost at once. So also young emus, rheas and cassowaries, tinamous, all the game birds, rails, cranes and bustards are clothed and active when they are hatched, and are able to follow their parents on the ground almost at once. The sand-grouse, which have the habits of game birds, although related to the pigeons, are born in an active condition. Shore and marsh birds, such as plovers, curlews, avocets and gulls, all of which lay their eggs on or near the ground, have active young. Rails, divers and grebes, screamers and all the swans, ducks and geese hatch out as lively, downy creatures, able to walk and run, and some of them able to swim from the first. On the other hand, penguins, which lay a single egg and incubate it on the feet, hatch out a blind and naked chick. Gannets and cormorants and petrels, which lay in holes in the rocks or in trees, all the hawks, eagles and owls, kingfishers, swifts and woodpeckers, pigeons, parrots and cuckoos, and all the perching and singing birds, hatch out their young in protected places and in a helpless, frequently naked condition.

Whether newly hatched birds already possess a covering of feathers or have to wait days or weeks to acquire it, the first plumage is usually very different from that of the adult, and a number of successive suits may have to be put on before the full dress of the adult is reached. The differences are partly in colour and partly in texture.

It is not easy to form a general picture of the differences in coloration between young birds and adults. The number of species of birds is enormous, and although naturalists have devoted themselves to collecting examples in the field and

forest, and to studying them in museums, with the greatest patience and enthusiasm, there remain many gaps in our knowledge, especially as to the changes that individuals pass through in the course of their lives. Nature seems to have lavished colour and pattern on the group, and to be displaying her eccentricities, her exuberance and her whimsicalities, rather than pursuing her usual orderly course. None the less it is just possible to get an idea of a general course of events, an idea, however, which must not be taken too rigidly, for there are probably exceptions which cannot readily be brought into harmony with it.

The colours of young birds are never brighter than those of their parents. There is one apparent exception to this, but it applies to the skin and not to the feathers. The naked and helpless nestlings which are reared in trees, in holes, and other rather dark and well-concealed places, are provided with heads that seem much too large for their bodies, and with mouths that seem too large for the heads. The mouths are actually enormous, and when the parent birds come carrying their spoil of worms or grubs, the huge opening seems even larger than it is, because it is marked at the sides with bright patches of colour, sometimes yellow as in the starling, sometimes white. The inside of the mouth is also brightly coloured, yellow perhaps being the most common tint, as in larks and thrushes, but red and yellow in some of the titmice. These colours fade away as the young birds grow, and it is probable that they serve as guides to the mother. A light may be unnecessary to find the way to one's own mouth, but a little help to the mouths of others may not be amiss.

The colour and pattern of the first coat of downy feathers, whether that appears before hatching or is acquired in a few days, never bear any intelligible relation to the coloration of the adult plumage. Very often indeed the colour is uniform, varying from pure white through dusky yellows and greens to pure black, and he would be an ingenious person who could trace any connection between the shades of the downy coat and the habits and surroundings of the young. The ostrich and the apteryx, the largest and the smallest of the flightless birds, are uniformly coloured, the

latter being of a dusky grey, the former grey with faint traces of the striping and mottling seen in the other ostrich-like birds, and appearing as if the marks had been washed out. Young penguins all wear a thick coat of down. The downy coat of the albatross is sooty-brown Pelicans are hatched naked, but in a few days their flesh-coloured skin is covered with a fluffy coat, pure white in colour. Flamingoes show no trace of the brilliant scarlet that decorates their adult plumage, but are snowy-white when they are in down. Newly hatched swans are pure white in some species, as, for example, in the case of the very beautiful black-necked swan, but more usually they are yellowish. Some of the geese and ducks, particularly the domesticated species, are clad in a monotonous uniform of white, which may be pure white, yellowish or dusky, but this is not the familiar uniform of their tribe The down of young owls is usually pure white. In most of the birds-of-prey the down is uniform; in ospreys it is clay-coloured; in the condor the head is naked, but the body is covered after a few days with a thin coat of white down. In vultures it is usually white, but may be yellowish or picked out with black on the wings as in the American black vulture, whilst in most of the eagles it is dirty yellow

The down covering of many young birds shows a conspicuous pattern of either spots or stripes, spots elongating to form stripes, or stripes breaking up to form spits. These patterns resemble in a most striking way the simple growth patterns to which I called attention in the case of young mammals. The arrangement is usually one that recalls the simple kind of bilateral patterns made by squeezing ink marks in folded paper (*see* Fig. 19, p. 77), and although the result may sometimes be of use in helping to make the young birds less conspicuous against the background, when they are squatting in the sunlight amidst reeds and other vegetation, or on a pebbly beach, they occur so constantly in many different groups of different habits that I find it difficult to think of them as special adaptations. They appear to be the more or less inevitable result of the particulate character of the skin and of the mode of growth. They have been retained in cases where they are either useful or harmless, but they are survivals

of an ancestral or primitive condition which have been preserved, rather than *new creations for the special benefit of* their possessors. Moreover, in many of the self-coloured chicks there are faint indications of obliterated stripes, which would seem to show that the plain-coloured chicks have more modern coverings than the striped and spotted forms

The nestling rhea or South American ostrich (Fig. 23, right-hand figure) is covered with a thick coat of long down feathers, dirty grey on the head and under surface,

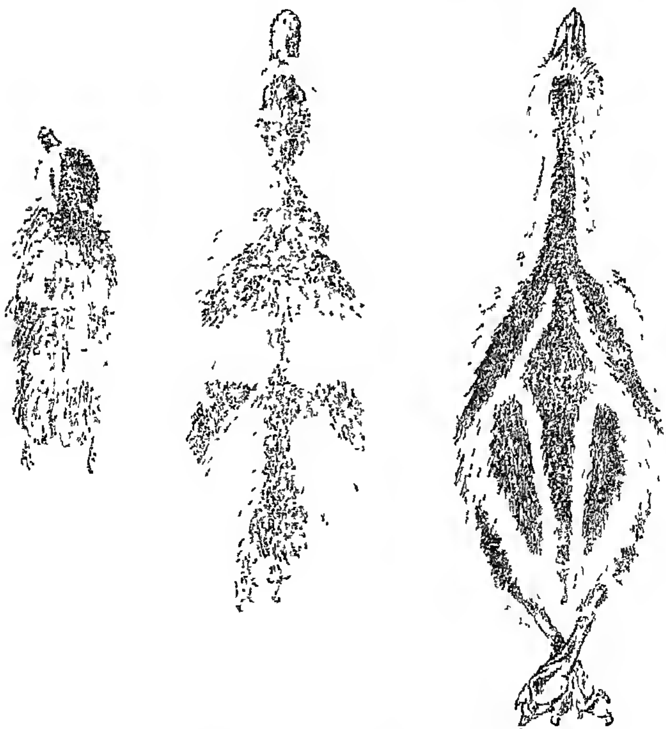


FIG. 23. Down-plumage Patterns. To the left a Summer-duck, in the middle a Sheldrake, and to the right a Rhea.

but with a long dark brown patch on the neck which forks over the wings, and is continued along the middle line of the back as a diamond-shaped mark tapering off towards the region of the tail. On each side of this a broad brown stripe runs backwards from the wings towards the tail, whilst a second stripe at each side runs along the outer surface of the thigh and leg. These brown stripes leave the pale grey background between them as narrow bands. In the young emu, the same general arrangement of dark stripes on a light background is present, but the stripes are partly broken up into rows of large spots. In the cassowary, the dark stripes are wider than the interspaces, so that the nestling looks like a dark bird banded with white. Grebes nest in the same marshy streams as many of the rails and moorhens, but the down of the nestlings is vividly striped, with dark bands running along the body. The nestlings are carried by the mother on her back, but so also are the self-coloured nestlings of swans.

A special but very simple pattern is found in many of the geese, like, for instance, the cereopsis goose, the sheldrakes (Fig. 23, middle figure) and the whole tribe of ducks except the domesticated breeds. The ground colour is a dirty white and this is retained on the under surface. The upper surface of the head is dark brown approaching black, and this is carried towards the tail as a broad stripe which expands to a diamond shape over the shoulders, with extensions running along the wings, and broadens out again towards the tail. Another dark band, which generally meets the median band, runs downward and backwards along the outer surface of the thigh. In the sheldrakes this pattern is very plain and leaves elongated spots of the white ground colour just behind the wings and the insertion of the legs. In the different ducks, the dark patches and stripes occupy more and more of the back until they may leave the ground colour showing only as a pair of bright spots opposite the insertion of the legs, and a less conspicuous pair of spots opposite the wings (Fig. 23, left-hand figure). Clearly, the geese and ducks show the gradual disappearance of the ancestral striped pattern and its replacement by a nearly self-coloured dark back.

Sooner or later young birds moult off their down if they have possessed it, and acquire a covering of true feathers. The feathers appear gradually, either on the naked body or amongst the down, and the time taken after hatching to acquire the first plumage may differ much in very closely allied birds. The emperor penguin remains no more than four months in the down, although the rather smaller king penguin does not assume its first true feathers for nearly ten months. The first feathers to appear are usually those on the wings and tail, especially in birds that live or nest on the ground or near the water. Young brush turkeys are able to fly almost as soon as they leave the egg. Fowls, pheasants, partridges, ducks and geese begin to have their wings well fledged in from a few days to a few weeks. In birds that nest in trees or holes, or high above the ground, the flight feathers usually lag behind the others. The time, however, is closely fitted to the habits of each species and has no general relation to the kind of bird or to the size of the bird.

The acquisition of a coating of true feathers, however, by no means implies that the young bird has acquired the pattern and colour of the adult. A number of successive moults, occupying one or more years, may have to be gone through before the young bird assumes its final garb. The facts are bewildering in their complexity and some of them are extremely difficult to place in an orderly picture. The general rule, to which the exceptions are extremely rare, is that the early plumages of young birds are duller in colour than the dullest of the adult garbs of their kind; that they resemble the young plumages of allied birds more closely than the various adult plumages of such birds resemble each other; that in colour they are extremely often brown, whatever be the colour of the adult plumages; and that in pattern they show such simple growth patterns as stripes, spots, bars and mottlings much more frequently than the adults.

The most familiar case of differences between young and adult plumages is that when the sexes differ, the young are like the plainer of the two adults. Everyone knows examples of this. In pheasants and fowls the cocks are amongst the most resplendent of living creatures. Their heads are decor-

ated with wattles, combs, coloured patches and crests. Their plumage shines with all the colours of the rainbow, with green and gold, purple and crimson, and red and yellow. arranged in the most fantastic of patterns. The cocks of different species are extremely unlike. The hens are clothed in subdued patterns, simple stripes and mottlings, coloured in various shades of brown, with at the most pale reflections of the glories of their mates. The hens of different species are much more alike, so alike that it requires attention and expert knowledge to distinguish them, whilst the poorest observer could be in no doubt as to the specific distinction of the cocks. The chicks in their first plumage are always very much more like the females and like the corresponding stages in other pheasants, and here again it requires an expert to distinguish them.

The likeness between the chick and the duller sex occurs even in those rare and curious cases in which the females are more brightly coloured than the males. Adult cassowaries have a deep black plumage, but the naked skin of the head, neck and legs is often coloured in brilliant and fantastic ways, the coloration being much more brilliant in the females, and in this case the young birds resemble the males. In some of the curious little button quails, or hemipodes, the sexes are alike, but in most of them the females are decorated with reddish collars and other conspicuous patches and marks, whilst the males are more dully coloured. The chicks in their young plumage resemble the males.

The best-known instances of the changes to "eclipse" plumage are found in the ducks, game birds, waders, herons, some of the tanagers and the weaver-birds. The little weaver-birds show almost every degree of likeness between the sexes; in some cases the males are very brightly coloured and the females dull, in others the colouring of the two is nearly alike. They pass into a dull eclipse and remain in that condition for nearly six months, and then assume the breeding colours again. The young birds are always more like the hens and the eclipse stages, the brilliant blacks, scarlets and purples being absent and replaced by mottled brown.

When both sexes are alike, the young in their first true plumage are usually unlike the adults and are much duller and browner. Examples of this occur in almost every group of birds. Sometimes the change from immature to adult plumage occurs at a single moult; sometimes gradually over two or three years as in the gulls, the feathers changing by almost imperceptible stages; sometimes, as in birds-of-prey, it takes a number of years, mottled and striped plumages being replaced by feathers with transverse bars, then by self-coloured feathers, and the general shade of the whole plumage getting darker. Many sea-birds are vividly patterned when adult, the under side being usually quite white, the upper surface black, or a shade of pearly-grey with black markings, or the whole bird, as in the case of the gannet, may be white except for the black tips of the wings. The young in their first plumage are nearly uniformly covered with shades of mottled brown. So also ibises and storks, which when adult are white, or brilliantly marked out with white, brown and black, wear a juvenile garb of mottled and spotted brown. The down of young pelicans is replaced by a uniform of brown before the brilliant livery of the adult is assumed. The American scarlet flamingo when adult is clad in scarlet and pink; the European white flamingo is white with scarlet on the under surface of its wings. Young flamingoes about two months old, with their beaks still nearly straight, have shed the nestling down, but replaced it by a plumage which is almost uniformly grey, with the faintest traces of scarlet on the wings. In birds-of-prey, adult males and females are so alike that it is most difficult to distinguish them, although the females are usually larger. The young, after moulting off their down, assume a set of successive liveries in which there is a slow change from dirty white, and mottled and spotted brown, to the brilliant blacks and whites and blue-greys of the adult. So also in owls, where the sexes are alike, the young differ from them, being usually paler, browner and more barred, striped and mottled. In doves and pigeons, where the sexes are alike, the young are usually more mottled, and especially in the brightly coloured fruit pigeons are browner and with little trace of the metallic sheens and

brilliancy of the adults. The common cuckoo is almost exactly alike in the two sexes; the back is uniformly ashy-grey with small white spots on the darker tail, and the under parts are white with dusky bars. The young, in immature plumage, which they wear until they are as large as their parents, are clove-brown above, and the feathers of the wing and tail are barred and mottled, so that the general appearance is strikingly different from that of the adult. The young of thrushes and fly-catchers are clad in a completely spotted plumage, but the adults are generally uniformly covered above.

When the sexes are alike or nearly alike, and especially when they are brilliantly coloured, the young in a few cases may be like the adults. In kingfishers the young are only a little less brilliant than the adults. In orioles, where the adults are usually very brilliant, the young are only a little less brilliant. In parrots almost every condition from dull to brilliant young is found.

Although the instances I have given are the merest samples of the fertile diversity of colour and pattern displayed by birds, they show the chief types of relation between the characters of males, females and young. It is possible to build up from them a general picture of a process that appears to have been going on. The older or ancestral types of birds displayed a plumage generally brownish in colour with little difference all over the body, and with patterns of spots and stripes and mottlings. At first the coloration of the young and of the adults in both sexes was more or less alike. Next, during the breeding season, the males began to assume brighter colours, and when the breeding season was over relapsed again into the dull coloration of their ancestors. In such a stage, the males in eclipse, the females and the young were all much alike, and traces of this condition survive in many existing groups. Next, the bright breeding plumage was partly assumed by the females as well as the males, but after the breeding time was over, both relapsed to the ancestral eclipse condition. In this stage, the males and females in eclipse and the young were like the ancestors. This stage too is retained by many birds, and the curious cases where the females have shot ahead of the males is

only another variation of it. Next, the breeding plumage was retained for a longer and longer period, for half the year as in the weaver-birds, for all but a few weeks as in game birds and most of the ducks, or for the whole year as apparently in the South American tropical ducks, in kingfishers and in parrots.

And so the general trend amongst birds and mammals alike has been from dull colours and mechanical patterns to brilliant and fantastic garbs. The set of changes has been attended and made possible by an increase in the vigour of the body and a heightening of the vital activities, so that respiration, excretion and all the chemical changes in the living laboratory have become more exuberant. The changes are an expression of surplus vital activity, for if animals are to succeed they must on the average be a little more vigorous than is absolutely necessary to attain their purposes. Now and again a successful runner may faint at the goal, but in most cases he can run a little beyond it. In the affairs of animals, as of men, some reserve is requisite. And so it is natural to find the beginnings of more brilliant colour and more vivid pattern associated with the breeding season, for in the breeding season the strength and vigour of animal life are most acute. It might be argued, as not a few naturalists have urged, that the cumulative beauty of animals is in itself accidental and inevitable, the mere result of their increasing strength and vitality, and there is no need to try to account for it by theories of natural selection.

Darwin was always careful to insist that natural and sexual selection were not the actual causes of the wonderful patterns and colours that are displayed in the animal kingdom. They were outcrops of the constitution of the body, by-products of its activities, and what happened was that when a colour or pattern that was useful appeared, it was favoured in the struggle for existence, or in the eyes of choosing mates, whilst colours and patterns that were harmful or that were displeasing were slowly eliminated. I do not think it can be doubted that in many case the spottings and mottlings and dull colours of young birds and mammals make them less conspicuous, and that it may be for this reason that they

have been retained in so many animals, in females that have to lie hidden during the breeding season, and occasionally in adults. They have not been created for the purpose of concealment, but they have been retained because they existed and were useful. So also the obliterating effects of counter-shading, the replacement of primitive patterns by ruptive patterns, and of dull colours by brilliant hues, may have come about in the natural course of physiological events and been retained where they were useful or harmless.

CHAPTER VIII

LIMITATION OF FAMILIES

ELEPHANTS may live until they are at least a century old, and do not begin to breed until they are well over twenty years of age. They are probably the slowest breeders of all animals, and a pair living to their full range of life under the most favourable conditions would not bring into the world more than six young ones. None the less, as Darwin calculated, if we could suppose that all the descendants of a single pair of elephants were to live to their full time of life, and to produce their six offspring, then at the end of the fifth century the single pair of elephants would be represented by over fifteen millions of living descendants. At the other end of the scale we may place a fish like the turbot, which can produce as many as fifteen million eggs in a season. I do not know how long it will live, if it escape being caught, but certainly it is capable of living a good many years. If all the descendants of a single pair of turbot were to survive, even the enormous area of the oceans would soon be filled with a solid mass of fish. A pair of London sparrows are able to rear three or four clutches of eggs in the course of a year, and each clutch contains from five to six eggs. The prolificness of animal life is enormous. Whether animals live a short time or a long time, whether they produce many or few young in a season, a sum in arithmetic shows that the air, and the surface of the earth, and the waters could soon be filled with the incredible swarms of progeny.

And yet we know that on the whole the relative numbers of different species of animals remain stationary. Now and again there is a grasshopper year, or a vole year, or a wasp year, when the destructive forces seem to have been swamped by natural increase. Some species of animals, such as man himself, are steadily gaining ground; others, like the bison in America or the antelopes and zebras in South Africa,

are disappearing; but on the whole the balance of life is preserved and, with occasional fluctuations, species neither gain nor lose very much in numbers. It follows, of course, that the natural rate of mortality must be very high.

Death falls most heavily on young animals. Physically they are more feeble and more readily succumb to extremes of heat or cold, to starvation or over-eating, to drought or rain, and to disease of all kinds. But their plain destiny is to be eaten. Young animals are more tender and succulent than old ones. Their fur, feathers, scales, bones and other hard parts offer less resistance to the teeth or claws and other biting and grasping organs, and offend the stomachs of their captors less than those of full-grown animals. They are not only a more attractive but an easier prey. They cannot fight or struggle much, they have feebler powers of escape, and less cunning and resource in avoiding their enemies. They form a great part of the food-supply of the world.

The ultimate source of the food of all animals is green vegetation. A vast expanse of verdure, trees, shrubs, grasses, ferns and moss covers almost the entire surface of the land from the tops of the mountains down to the edges of the sea. All this green vegetation is actively building organic food-material from the inorganic elements of the air and the soil. And so on the land vegetarian animals are more prolific and abundant than carnivorous creatures. Plant-eaters like sheep and cattle, deer and antelopes, rabbits and kangaroos are found in huge numbers and multiply at incredible rates. So also seed- and fruit-eating birds are more numerous than carnivorous birds; grasshoppers, locusts and vegetarian beetles than their carnivorous allies. But all these are preyed upon by carnivorous mammals, birds, reptiles and insects. In the sea, on the other hand, most of the animals are carnivorous. The birds that live on the ocean, terns, gulls, petrels, cormorants, are very numerous indeed, and the clouds of sea-birds in their breeding-places recall the dense vegetarian population of the land. These sea-birds are all carnivorous; most of them are fishers, and others, like the petrels, scoop up the small crustacea from the surface of the waves. Seals pursue fishes; polar bears live on seals; sea-

elephants and walruses live on shell-fish; whales, dolphins and porpoises all live on sea-animals, and many of them are fierce beasts of prey. Most of the lower forms of life are carnivorous. The gardens of the tropic island sea-bottoms, with their brilliantly coloured, flower-like polyps, are composed of animals that live on other animals almost exclusively.

A small portion of the ultimate food-supply of the sea consists of the flotsam and jetsam from the land, of waste matter washed down by the great rivers. But the main source is to be found in the sea-water itself. If the open sea seems at first a barren waste, the tow-net shows that it contains myriads of small animals. These are the larvæ of innumerable creatures that live on the shore or on the bottom, together with countless wanderers that have no fixed abode, but drift all their lives with the ocean currents. Amongst them are great numbers of small plants, like the protococci that form the green scum on pools of rain-water, or the diatoms familiar to every one who uses a microscope. These, in the fashion of terrestrial green plants, build up food-material from the inorganic salts in the sea and from the gases of the air. Little animals live on them and are in turn fed on by larger animals. In the depths of the ocean, where no light penetrates, green plants cannot live, and the food-supply must be derived from live or dead animals that rain down from the surface.

And so on land and in the sea, in the air and in the waters, living creatures are ceaselessly devouring other living creatures, and the feeble and succulent young are the readiest victims. The more powerful carnivorous animals seem to rejoice in their strength and skill, and many of them destroy far more victims than they require for food. Others are extremely voracious, and appear to have no limit to their capacity for digestion or to their appetite. If we reflect on the dangers from accident, disease and the host of hungry enemies, the wonder seems to be, not that species occasionally have become extinct, but that any have maintained their existence.

The most common device in the animal kingdom to meet the immense destruction of life is for the young to be produced in enormous quantities. In the sea especially, where most animals are carnivorous, the ripe females are bloated

with a great burden of eggs, to be counted by millions or thousands or hundreds, and large tracts of water become changed in colour because they swarm with innumerable multitudes of tiny embryos. Although amongst the higher animals we count large families by sixes and tens, instead of by hundreds and thousands or millions, we know the amazing fertility of many small mammals and birds.

To produce a large family, making little provision for it, is a wasteful and improvident method of maintaining the species. To limit the number of the young, to lavish on them parental care and not to throw them on their own resources until they are well fitted to make a brave fight against the troubles of the world, are surer means of maintaining the numbers of the species and enabling it to reach a higher level of efficiency. Devices of this kind have been adopted in almost every group of the animal kingdom, but become more universal and more complete as the scale of life is ascended. Not only are the numbers in the family reduced, but the period of youth becomes longer. The protected young are no longer at once absorbed by the immediate problems of life, by the struggle for mere existence. They form in each division of the animal kingdom a kind of aristocracy with leisure for education and training, and with the opportunity of modifying instinct by practice. The word family in their case acquires a new and real meaning. It no longer is a name simply for the offspring of a single pair of parents, but comes to imply an association of brothers and sisters, of young and parents living together in a new relation, not merely temporarily united by the attraction of sex, but forced to live together in some kind of harmony, with some degree of mutual toleration. The appearance of the family provides opportunity for developing the social habits which are the foundation of the higher sides of mental and emotional life. Co-operation, friendship and love which is not sexual attraction find their first beginnings in limitation of the numbers of the young and in the association of young and old in the family tie.

In the lower animals the limitation of the numbers of the young and the institution of parental care are often associated

with specially hard conditions, and are found amongst creatures that live in very cold water, as in the polar regions, or in fresh water, where the strong currents and rapid changes of temperature are hostile to the feeble young, or in the strenuous and storm-tossed life of the shore. It may well be that of the multitude of young produced, only those that accidentally remained with their parents survived, and that afterwards the total number was gradually reduced and the arrangements for retaining the young with their parents made more perfect. In most of the sea-urchins enormous numbers

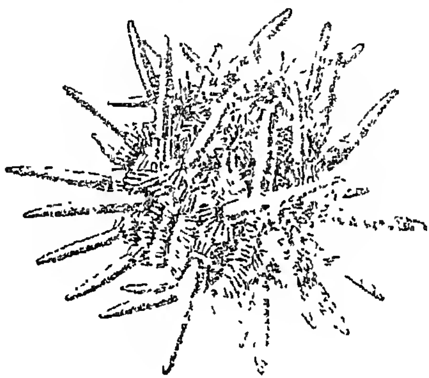


FIG. 24. A Sea-urchin carrying its young. (*After* WYVILLE THOMSON.)

of eggs are discharged every season; the number in the common edible form sold in the markets of the south of France and Italy has been calculated at twenty millions. These eggs are fertilised in the sea and the young embryos drift without any help or protection from their parents. In some of the urchins from the Antarctic seas, Sir Wyville Thomson found that there were little shallow pouches on the outside of the shell or test of the female, and that the spines bordering these were long and curved over to form basket-work lids. The eggs, comparatively few in number, were passed into these pouches and there developed directly into small urchins, which thus enjoyed the security and protection

given by the mother until they had reached a considerable size (Fig. 24). So also the most common sea-cucumbers produce eggs in enormous numbers, and these develop into unprotected embryos in the water. In a sea-cucumber from the Falkland Islands the two rows of tube-feet (the *bivium*) along the dorsal surface are rudimentary, and not used for locomotion in the females; along these a dozen or so of little animals are attached, looking like a row of yellow plums, and remain there until they are nearly fully grown and able

FIG. 25. A Brittle-star carrying its young. (*After* WYVILLE THOMSON.)

to live the independent lives of the adult. Although in most starfish and brittle-stars large numbers of young have to encounter the huge mortality of a free life in the waters, in others only a few are produced, and creep about on the body of the mother (Fig. 25) or develop in a brood-pouch formed on the outer surface of her body.

All the crustaceans have gone a considerable way in the reduction of the number of eggs produced and all of them display at least the beginnings of parental care. In a very few, including some of the fish-lice, the eggs are attached by

the mother to water-weeds or stones. In most they are carried about by the female in a brood-pouch, or attached to the legs or to a special chamber formed from the flap that protects the external gills. When the eggs hatch, in most cases free-swimming larvæ emerge, and these without further aid from the parents are transformed to the adults by a series of moults. During their larval life, however, prodigious numbers are destroyed, for crustacean larvæ form a most important part of the food-supply of fishes and aquatic birds, and the different groups supply many cases of a still greater protection of the young by the parents, with reduction in the number produced and a much higher percentage of success in reaching adult life. The summer eggs of the little water-fleas (Cladocera) are hatched in a brood-pouch under the shell on the back, and in some cases are fed by a nutritive juice which reaches them from a large blood-space. In many others, the eggs are carried in pouches attached to the body of the parent, or are suspended to her legs. In all these small flea-like crustaceans, however, the development is indirect, and at least some metamorphoses are gone through. In the sandhoppers and slaters the numbers of the young are still further reduced, and the embryos, carried by the mothers in brood-pouches, are fed and protected until they have almost completely attained the adult structure. In the higher crustaceans, such as shrimps and prawns, crabs, lobsters and crayfishes, the eggs are rather numerous, and are cemented to the under surface of the body of the mother, forming the familiar "berries" which in prawns, crabs and lobsters turn red on boiling. In those that live in the sea, when the eggs hatch, the larvæ leave the mother and have to fend for themselves. In the fresh-water forms, however, such as the familiar crayfish, the eggs are much larger in proportion to the size of the animals, and are much less numerous. The complete development takes place before hatching, whilst the egg is still carried by the mother, and when the young creature emerges it is almost a perfect miniature of the parent. It enjoys the protection of the mother for a still longer period, clinging to her with its pincers.

Scorpions and spiders are terrestrial, air-breathing creatures

of high organisation, and show many instances of elaborate precautions for the care of the young, and of a resulting reduction in the numbers of the brood. Scorpions are the larger, more powerful and better armed, and in them the process has gone farthest. The eggs are hatched inside the body of the mother, and each brood consists of no more than about a dozen individuals, which are born two at a time. From their first appearance they can be recognised as little scorpions, differing only in size, in paler colour and in a few minor details from their parents. They at once find their way to the back of the mother, and the whole family is carried in this way for some weeks, until the young creatures have gone through several moults and become large enough and strong enough to look after themselves. During this time they enjoy protection, for a scorpion is a formidable creature with few enemies sufficiently daring to attack it. The young feed on scraps of the spiders, cockroaches and other insects which the mother catches and slowly picks to pieces.

Spiders are far from having reached the economy of breeding habits shown by scorpions. The young are always hatched outside the body of the mother, and although they are plainly spiders at their first appearance, they go through a number of moults before they are capable of independent life. They are fragile and delicate little creatures and suffer great destruction from storms of wind and rain, from drought and floods, and although the numbers produced at a brood are very much reduced from the enormous quantities found among marine animals, they are often large. The numbers are proportioned to the special difficulties to be met, and in some of the spiders that live in the safe retreat afforded by dark caves there may be no more than four or five eggs.

Maternal care begins before the eggs are laid. Most female spiders spin a little web of silk, deposit the eggs on this and then cover them up with another layer. The egg-bags, or cocoons, are often distinctively shaped and coloured. When young spiders hatch they are pale in colour, and as they are covered with a thin membrane, can neither spin nor eat. After a few moults they differ from the parents only in size. Until two or three moults have been gone through, and this usually

occupies about a week, the young spiders remain near the cocoon or the mother.

Sooner or later, however, spiders have to disperse to avoid the reawakened instincts of their mother and the fierce attentions of their hungry brothers and sisters. Many of them do it by a curious device, making use of the wind like the winged or tufted seeds of plants. On a fair but windy morning they climb up to the highest point available, to the topmost bar of a fence, to the edge of a high wall or to the extreme twigs of bushes. There they raise themselves on the ends of their legs with the abdomen held erect and pointed backwards away from the wind. Then little tufts of delicate silk are shed out from the spinnerets and float in the breeze until they are long enough and have enough surface to carry the spider from its support. The caprice of the breeze determines the course and distance of the flight, but just as a spider can haul in the thread which binds it to a spot from which it has dropped, so when it is floating it can roll up its sail, piece by piece, until it descends to the ground.

Insects in every stage of their lives suffer greatly from the inclemency of the weather, the ravages of disease, and the attacks of other insects, of spiders, and especially of frogs, reptiles, birds and mammals, many of which live almost entirely on an insect diet. Some insects are extremely prolific, but none the less, especially in the higher members of the higher groups, the old thriftless method of large broods left to take their chance in the world is replaced by smaller broods for the safety of which great precautions are taken. It is a singular fact that in by far the greater number of cases the provision for the young is made by parents destined never to see their offspring, and who are nearly always dead even before the eggs have hatched, and it is therefore only in a very few cases that there is an actual association between the hatched young and their mothers. The provision seldom extends to more than selecting or preparing a suitable place in which the eggs may hatch and where the larvæ when they emerge may have the proper surroundings and the proper food.

Among the orthopterous insects the eggs are rather numer-

ous, and are frequently scattered on the ground without any precautions. The common earwig, however, has been observed collecting her eggs with her mandibles, arranging them in heaps and brooding over them. When the young emerge, the mother takes no further interest in them, and after a few moults they are completely like the adult. Cockroaches enclose the small number of eggs they produce in a cocoon, which is formed in the interior of the body. When the cocoon leaves the body, it is carried about by the mother for some time and then hidden in a chink, or, in the case of the common cockroach, most frequently just under the edge of a carpet or sheet of oil-cloth. The praying mantis constructs a chambered egg-case, which it attaches to wood or stones. Leaf insects and stick insects deposit very large numbers of eggs almost at random, and the young soon after they are hatched usually have the appearance of their parents, although some, such as the Ceylonese stick insect, go through remarkable changes of shape and colour. Female green grasshoppers have nearly always a long ovipositor at the tip of the abdomen, and with this dig a shelter for the eggs. Crickets have a long ovipositor, and do nothing for their young after the eggs have been laid in a suitable hole. The mole-crickets make burrows for themselves underground, using their strong spade-like front legs for the purpose, but the female also constructs a special chamber in which about a hundred eggs are laid and where there is a space for the newly hatched young to lurk.

The termites, or so-called white ants, which, however, are related to may-flies and dragon-flies rather than to ants, show one of the most remarkable developments of family life in the animal kingdom. The conditions differ a good deal in different species. Each colony is really a patriarchal family, the descendants of a single pair living with their parents in a community and playing different parts in it. One of the simplest cases is that of a European termite the habits of which have been studied in Sicily. A winged pair take up their abode in a dead or decaying tree, living on the rotting wood and hollowing out chambers and burrows. They reproducc slowly, being surrounded by fifteen or twenty young

after the first year, but more rapidly afterwards, and in a few years the family may reach as many as a thousand. The eggs that hatch out produce larvæ which are at first true males and females. Some of these develop slowly, and in rather more than a year become perfect winged insects, and leave the colony in pairs to found new colonies elsewhere, after having spent their youth, so to say, as servants in their parents' house. Other individuals develop more quickly, but when fully grown are blind and wingless. Their reproductive organs remain in a condition of arrested development, and their jaws and heads become of enormous size. In the more highly developed colonies, these individuals, known as soldiers, are fed differently, and it appears as if the peculiar food they receive were the stimulus to their different mode of development. The use of the soldiers is to defend the colony, by blocking up apertures with their enormous heads and powerful jaws, threatening, attacking and driving away enemies. In their youth these warriors have undergone a kind of forced conscription, but they have been so shaped and trained for their special functions that they cannot resume the normal life and normal functions of perfect individuals.

In some of the numerous African species of termites which construct chambered dwellings many feet high, the colonies are much more elaborate, but remain essentially single families, all being the descendants of one pair, the king and queen. These lose their wings, and the queen becomes enormous in size, and lays almost incalculable quantities of eggs. The larvæ that hatch out are at first much alike, but, owing partly to differences in food, some remain small, blind and wingless, with arrested sexual organs, and live their whole lives as workers, constructing the chambers, providing the food, tending the king and queen, soldiers and young. Others also remain blind and wingless, but grow several times as large as the workers, and develop enormous heads with strong jaws or with peculiar snout-like protrusions from the forehead; these also remain in a condition of arrested sexual development, and act as soldiers or warriors, being useful only for the defence of the colony. Finally, other larvæ develop into perfect winged insects, male or female, and leave the colony

in great numbers, most of them perishing, but a few becoming the founders of new colonies. These elaborate communities may consist of many thousands of individuals, but they remain a single family, and it is believed that, whilst occasionally a new king and queen may be reared, in most cases the community perishes when the original founders die.

The gall-flies are provided with a delicate ovipositor, and by means of this the females pierce the tissues of plants to deposit their eggs. Some of them, however, use their weapons to insert their own eggs into the actual eggs, or more often the soft larvæ, of other insects, and the young when they hatch are thus provided with a living prey. The ichneumon-flies have similar habits. They prey chiefly on the caterpillars of butterflies and moths, and when they have found a suitable victim, which may be many hundred times larger than themselves, swoop on its back, pierce the body with the ovipositor and leave their eggs in it. The larvæ thus hatch out in a favourable and protected position and eventually devour their unwilling host. In many cases their ravages are so timed that the caterpillar is not killed before it has pupated, and its parasites then go through their own pupation within the chrysalid. Those who breed butterflies and moths have to take sedulous precautions to keep off ichneumon-flies from the eggs and caterpillars they are rearing, and none the less often find that at the time when the butterfly should appear there comes out only a swarm of little flies.

The females of the gaudy little ruby-flies haunt places occupied by solitary wasps. When one has discovered a cell with a young wasp larva in it, together with the store of caterpillars that the wasp has placed for the benefit of its own grub, she places a few of her eggs in it, and the larva devours not only the wasp-grub but the caterpillars stored for the latter. These ruby-flies which have thus learned to provide so well for their young lay very few eggs, and of those that are laid usually only one hatches out.

The larvæ of bees are soft, legless grubs, and are placed in cells constructed by the mothers themselves in the case of the solitary bees, or by the arrested females known as workers in the social bees, whilst in some parasitic bees the mothers

deposit the eggs in cells constructed by other bees, and the parasitic grubs hatch out more quickly and devour the food prepared for their host. In the solitary bees each cell is packed with a mixture of honey and pollen collected by the mother: in the social bees the food is collected by the workers, who feed and tend the young.

The female solitary wasps construct a cell for each egg, in which they store from eight to a dozen caterpillars, which are paralysed by the sting and so remain fresh and alive until the wasp-grub is ready to devour them. Amongst the social wasps, each colony or nest is really a family founded by a single female which has hibernated. In spring she selects a suitable locality and lays the foundation of the nest, depositing an egg in each of the first few cells. The grubs hatch out quickly. and then the female devotes all her attention to feeding them, bringing at first sugary material which she collects from flowers or from any store she is able to rob. When they are a little older, she chases and captures living insects of different kinds, breaks their bodies into a pulp by her strong jaws and supplies this animal diet to the growing young. The first set of young mature into workers, which are really imperfect females, and these at once devote all their time to improving and enlarging the nest, and to foraging for and tending the successive series of eggs which the queen continues to lay.

In the communities of ants, which, unlike those of wasps and bees, last for a number of years, there are usually more than one queen or fertile female. The eggs hatch out into little grubs, which are fed and tended by the workers with a care and intelligence far surpassing the qualities displayed by any other invertebrate animals. The grubs are moved from place to place in the nest according to temperature or moisture, are kept clean, and are frequently carried above ground for an airing.

Beetles as a rule lay a considerable number of eggs, and do no more for the next generation than choose a suitable place for the larvæ. Butterflies, moths and most of the true flies and bugs present every gradation from the almost random deposition of a very large number of eggs to the

careful selection of a food-plant or food-material on which the eggs are laid, the number being then smaller. Occasionally the eggs are deposited in burrows that are excavated in the tissues of plants or in wounds made in the bodies of animals.

Many of the marine molluscs lay enormous numbers of eggs and make no provision for the young. The common edible oyster begins to breed when it is three years old, and the spawning season lasts from April to August, beginning rather later in cold years. The eggs hatch out inside the gill-chamber of the parent and emerge as little free-swimming larvæ, and it has been calculated that from three hundred thousand to six millions may be discharged by one oyster in a single season. A very large proportion of the embryos perish, for they die unless they succeed in finding suitable ground to fix themselves within a day or two. Those that adhere to some solid object, such as a piece of stone, lose their cilia and begin to grow rapidly, being small oysters about an inch across at the end of the first year and thereafter increasing at the rate of about an inch a year. In the common freshwater mussel, although the number of eggs is still very large, being from fourteen thousand to a million, development has proceeded further before the embryos are discharged from the gill-chamber of the mother. The ciliated free-swimming stage is passed through before hatching, and for a few hours the tiny embryo swims about inside its own eggshell, thus recalling the free-swimming state of its remote marine ancestors. After hatching, the embryo, still within the gill-chamber of its mother, grows into a peculiar larva known as the glochidium, with a shell consisting of two valves hinged together, with strong teeth on the free margin of each shell and with a long, sticky thread protruding from between the shells. These larvæ are then ejected by the mother into the water, and they fall in masses to the bottom, the long, sticky threads forming a tangled mass, like the web of a spider. Most of them die, but if any small fish, attracted by the gelatinous mass of larvæ, come near, then the glochidia become excited, flap their shells actively, and so straighten out the byssus thread. If one of these threads touches a fish, it adheres,

and the tangled mass, consisting perhaps of many hundred larvæ, is dragged behind the fish. As the fish wriggles about, some of the glochidia are sure to be brought in contact with it, and any that do so at once seize hold firmly with the toothed edges of their shells, snapping them tightly together. Those that have laid hold of a hard spine soon die and drop off. Those that have lighted upon one of the gill filaments or the fleshy part of fin or tail cause a slight inflammation in the tissues of the fish and by the growth of these become enclosed in a cyst. Within this they live on the juices of their host, are carried about by it, and go through the rest of their development until they are perfect little mussels. In the meantime, just as a thorn that has not been extracted is gradually sloughed out of the human skin, so the cysts containing the mussels are set free from the fish, and the mussels drop into the mud and begin the normal adult life of their kind. The fish that are chosen as the walking nurseries and feeding-ground of the young mussels are usually sticklebacks, but minnows and loach serve equally well.

In the air-breathing land snails, which must be regarded as the most highly developed members of the group, the eggs are rather large, sometimes enormous, have stout shells and enough food-yolk for the nutrition of the embryo until it is fully formed. The numbers are much reduced and the eggs are generally hidden in some secluded place, in nests at the roots of plants, covered over with soil, or wrapped in leaves on forest trees.

In the various invertebrate animals the limitation of families and the provision for the young are chiefly economic in character. The supply of food and the protection afforded the young during their most tender stages have brought about a greater security that the species will be maintained. Incidentally, however, they have been associated with considerable changes in the mode of growth of the young. As these have no longer to secure their own living, it is possible for the mode of development to be more direct and for various ancestral stages to be cut out. It has led, moreover, to very important modifications of instincts. We think of the care bestowed by parents, and especially by a mother on the young, as springing

from affection, but it happens often amongst invertebrates that such care is devoted to offspring that the parents will never see and exhibited by animals to which it is difficult to attribute any emotions. The emotional quality of affection really comes later than the duties and cares and devotion of maternity. It is a consequence and not a cause of parental care. The modification of instinct that it reveals is very striking. The first business of any animal is to look after itself, to provide for its wants, to satisfy its own appetites, and especially in the case of carnivorous creatures to regard every living and moving thing as prey to be seized and devoured. The mere toleration of the young by the mother is a new beginning in life, and is the foundation of many of the highest qualities displayed by the highest animals and by man himself.

The relations of the young to the mother are less surprising. They are a continuation of the organic relation by which the young are born of the body of their mother, and they exist and become, so to speak, a habit before the individuality, the physical powers and the senses and aptitudes of the young are really awakened. And so in the same way the relations of the young of the same family to each other precede consciousness and real individuality. The eggs are laid in a mass, in the same cocoon or in the same supply of food, and the young grow up together necessarily tolerant of each other's presence. The swarm of caterpillars clustering on a single branch, the globe of young spiders cohering round the remains of the cocoon at first mean nothing except the accident of contiguity. In most cases, as soon as the individuals have reached a certain degree of development or of size, they separate if they are vegetable-feeding creatures, or begin to attack each other and so forcibly separate if they are carnivorous. But the existence of cannibal larvæ, even as rare exceptions, of instances where the first larva to be developed devours its fellows, throws into stronger light one striking result of the economic limitation of families and the compulsory association of the young. It has created the necessity for a modification of the predatory instincts of carnivorous creatures and has led to the existence of a power of recogni-

tion and selection. Certain things in the surrounding world they attack and eat; other things are taboo, not to be attacked and not to be eaten.

The most important result of the institution of family life amongst invertebrates is the appearance of the social communities of termites, bees, wasps and ants. The termites are the simplest case. They form a real family, and all the individuals are potential males and females. The workers and soldiers are at first not more than young animals which have to pass a period of servitude in the paternal home, ministering to the needs of the community, before they go out into the world to lead their own lives. From such a condition has come about the strange existence of individuals so modified for their early duties that they cannot pass on to the normal duties of normal individuals. In the social wasps and bees there is the further complication that only females are selected to do household work, and modified so that they lose the ordinary selfish instincts and devote themselves entirely to the purposes of the community, whilst the males develop only the instincts and capacities of sex, and when they have served their purpose are turned out to die. In the communities of ants, as in termites, there are individuals modified to serve as workers and as soldiers, but, as in wasps and bees, these are all arrested females, and the males are used only for the purposes of sex. The colonies of ants last a much longer time than those of bees and wasps, which are annual, and this has given the possibility of a more intricate civilisation being developed and of much more complex instincts being formed. When we think of the elaborate ordering of a community of ants, of the care devoted to the young, of the capture of other ants and their use as slaves, of the domestication of aphides and their use as milch cows, of the cultivation of fungi to be used as foods, it is plain that there is nothing comparable until we reach the highest organisations of civilised man. And yet these have come about as a by-product of the formation of families.

CHAPTER IX

BROOD-CARE AND LIMITATION OF FAMILIES IN LOWER VERTEBRATES

I HAVE already mentioned the prodigious fertility of many fish. Most of the bony fish lay eggs in numbers that can be estimated only in figures ranging from hundreds of thousands to millions. Those in the ovary of a ling have been estimated at over twenty-eight millions; in a turbot of only seventeen pounds weight, nine millions; and in a cod of twenty-one pounds weight, six millions. These eggs are extremely small and are discharged directly into the water by the female, after which she takes no further notice of them. They are known as pelagic—that is to say, whether they are shed by fishes that spend their lives swimming either at the surface or at no great depth, such as cod, whiting, hake and ling, mackerel, pilchards or sprats, or by fishes which live on the mud or sand at the bottom, they speedily rise to the surface and float in the warmer water exposed to the light and heat of the sun. They are transparent, almost invisible glassy spheres, each buoyed up by a clear droplet of oil. At the usual spawning time, April or May in northern waters, the whole surface of the sea is turbid with the innumerable floating eggs and newly hatched young, in the favourite places for breeding, which are usually the rough waters of bays, or near shoals on which the tides break. The eggs contain very little food-yolk, and the tiny fish, as soon as they hatch, have to begin feeding themselves. They are omnivorous, and find an abundant prey in the still more innumerable young stages of various crustaceans, molluscs and worms. The destruction is enormous; the larger fishes devour the smaller; great flocks of sea-birds, gulls, guillemots and gannets, scream and squabble as they gorge on the larger fish; whilst whales and dolphins come to join at the feast. Other agencies share in the work of destruction; a heavy night-frost, a torrent of

rain or a storm of wind may destroy millions.

Other kinds of fish descend to the bottom of the sea and lay submerged or demersal eggs. These are larger and are heavier than sea-water. Herrings, although they swim near the surface, lay demersal eggs, and a similar habit has been adopted by the wolf-fish, gobies, suckers and many others. A certain amount of choice is shown in the selection of the ground for depositing the eggs, and these are usually enclosed in a firm and sticky capsule, or embedded in lumps of mucus which enables them to adhere to seaweed or stones. The numbers are much smaller, and are to be counted in thousands, hundreds or dozens. The herring, which is the most prolific of these fish with demersal eggs, deposits about twenty thousand. Fishes, like salmon, which ascend rivers from the sea, and most of the fresh-water fish, are also demersal, and many of them show a certain amount of care in the deposition of the eggs, scooping out holes and covering them with sand or stones.

There is a heavy toll taken of unprotected demersal eggs, and there are many remarkable instances in which brood-care goes much beyond the mere choice of a locality for laying the eggs. The spawn is often sedulously guarded by one of the parents, and it is interesting that this duty is almost invariably assumed by the male. The female lump-sucker attaches her eggs in sticky masses to rocks or logs and then takes no further interest in them, but the male watches over them until they hatch out, when the fry cling to his body by their suckers. J. S. Budgett, who went to the Gambia to study the strange African lung-fish, *Protopterus,* found that the eggs were laid in circular nests hollowed in the mud on the edges of swamps. The female apparently deserted the nest after laying the eggs, but the male stayed on, and was usually found lashing his tail and keeping the water in violent commotion, so that it was better aerated. The male guarded the young larvæ savagely, biting at any one who tried to touch them. The young larvæ grew suckers on their heads like those of tadpoles, with which they fastened themselves to the sides of the nest. In the same locality Budgett found the floating nests of *Gymnarchus niloticus,* which were a foot

and a half across and surrounded on three sides with a rim of twisted weeds, the fourth side being under the level of the water. The male kept a fierce watch over the larvæ in the nest, snapping viciously at intruders.

The American bullheads or horned pouts resort in pairs to the muddy shallows at the edges of the fresh-water lakes they inhabit. In water a few inches deep they gradually make a hollow in the side of the bank, throwing out the mud and sand until a mound is formed on the bottom with a shallow groove leading to the opening into the nest. After the eggs are laid, one or both parents remain to guard the young larvæ, and then swim out with the shoals of little fish. Shoals from different nests have been observed to join temporarily, but afterwards to separate, so that it seems as if the corporate life had led to a definite sense of recognition amongst the members of each brood.

The nesting habits of the little sticklebacks which live in fresh, brackish or salt water are well known. The male is the housebuilder, and uses weeds and twigs as his material, fastening them together with a sticky secretion from the kidneys. When the female has deposited her eggs in the nest, she deserts it, and the male continues to guard nest, eggs and young fry with the most pugnacious spirit.

A few fishes reduce the number of the family still further and protect it by carrying about the eggs and young larvæ. The well-known sea-horse (*Hippocampus*) (Fig. 26), which carries itself erect when swimming and looks like the knight of a chess board, has a pouch in the male, on the front of the body opposite the root of the tail, and in this the eggs and young larvæ are carried about. Most of the catfish protect their young by making nests and guarding them with fury, more often the male, but sometimes the female; sometimes both sexes performing this duty, and afterwards herding the shoals of fry when they emerge. In a few catfish the number of eggs is still further reduced, and the male or the female, according to the species, carries them in the mouth and pharynx, a very singular case of the subordination of the normal appetite to an unselfish duty.

In nearly all the bony fish the eggs are fertilised after they

have left the body of the mother, and their subsequent development, whether they are turned adrift or guarded in some of the curious ways I have mentioned, is really independent of her. But in a few instances not only is there internal fertilisation, but a large part of the development takes

FIG. 26 Male *Hippocampus*, showing brood-pouch. (*After* MURRAY.)

place in the ovary of the mother, and the young larvæ are fed not only by the small amount of yolk deposited in the egg, but by a secretion from the walls of the ovary which they swallow and digest. The blenny is the best-known case of this device. The eggs are hatched in about twenty days, but

the young are not actually born until they are several months old, by which time they are nearly two inches long and are like the parents except in size.

In all Elasmobranch fishes, fertilisation is internal and the eggs are very large and few in number. The breeding season extends over the greater part of the year, and only one or two eggs are ripened at a time. After it has been fertilised, the egg is enclosed in a brown horny case, often oddly shaped, usually oblong or quadrangular, with a hook or long tendril at each corner. In some rays and the common English spotted dogfish these egg-cases are deposited on the sea-bottom, or their tendrils are twisted round a strand of sea-weed. The secure position and the large and unpalatable case protect the developing embryos for several months, after which the young fish, now able to look after themselves, escape through a slit in the egg-case. In most of the dog-fishes, as, for instance, in the common smooth-hound, in many rays and in sharks, the egg-case is very thin and delicate, the quantity of food-yolk in the egg is much less, and the eggs are retained in the body of the mother, lodged in special expansions of the oviducts, until the embryos have hatched and grown to young fish. The walls of these sacs form long filaments, supplied with blood from the vessels of the mother and serving for the nutrition of the young. In some cases this secretion is swallowed by the embryo in the same way as in the viviparous blenny. In other cases, the nutritive filaments of the mother are arranged in a pair of bundles, one of which is thrust through each spiracle of the embryo into its alimentary canal, where the nutritive secretion is taken up. There is a still higher development of this mode of maternal nutrition of the embryo in some of the sharks, which recalls the embryonic stages of mammals. The blood-vessels of the embryo grow out over the yolk-sac, and absorb the yolk and use it for the growth of the embryo. When the yolk-sac is exhausted of its contents, the blood-vessels covering it grow out into tufts which intertwine with similar vascular tufts arising from the tissues of the mother, and through such a placental connection the blood of the mother conveys nutrition to the embryo.

Thus in various ways and by many different devices the number in each brood of fishes becomes reduced in many species. Instead of an enormous number being discharged to take their own chance, a few are protected, sometimes fed, and only set free when they have attained some degree of strength and capacity for protecting themselves. As in lower animals, apart from its consequences in better securing the maintenance of the species, this changed mode of reproduction has a number of by-products. The growth of the protected embryos, especially when they are supplied with much food, either in the form of yolk or later on from the tissues of the mother, is more direct and less a repetition of the ancestral history. The instincts of the guardian parent or parents have become diverted to new directions. Instead of being occupied throughout their whole lives with their own individual concerns, the parents devote some time and much trouble to matters which affect the safety of the species rather than their own individual safety. They take substances into the mouth, such as eggs, which would be good to eat and yet do not eat them. They watch over, swim about with and protect from others little moving creatures which a few weeks before or a few weeks afterwards they would greedily devour. The young, too, occupying the same nest, swimming in the same shoal and following the same guardian, acquire some power or habit of association which, if it were conscious, we should call recognition.

Later on most fishes break away from the shoal and live strictly individual lives, but there are not a few which continue to move in masses throughout their lives, showing concerted action and a feeble beginning of the social instinct.

Most of the tailless batrachians, the frogs and toads, and many of the tailed batrachians, the newts and salamanders, lay a very large number of eggs, and exercise the least possible discrimination in their selection of a spawning-ground. Nearly all the tailless batrachians live in or near the water, and the eggs, which are very numerous, are deposited in water with no special precautions. In a few, such as the spotted salamander, the eggs are retained in the body of the female until they have actually hatched or are on the point of hatch-

ing; whilst some, such as *Amphiuma* and the Cœcilians, lay their eggs on land and protect them by coiling their bodies round them.

Amongst the tailless forms, however, brood-care may reach a much higher level, with a consequent reduction in the number of the young. *Hyla faber*, a Brazilian tree-frog, descends to the water to breed, a male and female associating, but only the female preparing the nursery for the young. She selects the shallow end of a pool and dives to the bottom, bringing up loads of mud on her head, which she gradually piles up to form the circular wall of a tiny pond, smoothing it with her hands on the inside and continuing her labours until the edge is raised above the surface of the water. The spawn is deposited in this little nest and the parents lurk near it for some days, but appear to take no special precautions for guarding the young. The male of the midwife toad (*Alytes obstetricans*), a common batrachian in Europe, winds a string of eggs round his hind-legs, immediately after they have been laid, and then retreats to a hole. At night he comes out to feed, and at the same time moistens the eggs, sometimes carrying them down to water and dipping them in it. After three weeks of nursing them in this careful way, the male carries them, now ready to hatch, down to the water, where the tadpoles emerge, and his responsibility ends. In *Rhinoderma darwini* (Fig. 27), a small frog discovered by Darwin in Chili, the male has a pair of sacs, normally used to increase the volume of the voice, which open into the mouth on each side of the tongue. In the breeding season the fertilised eggs, which are only from five to fifteen in number, are placed in this, and as the embryos develop, the sacs expand until they occupy the whole of the lower surface of the body under the skin. Not only hatching takes place in this secure retreat, but also the further development of the young, which do not emerge until they are miniatures of the adult.

In all reptiles the number of the family has been greatly reduced, and not more than from six or seven to about one hundred are produced at a time, except in some of the turtles and tortoises. The eggs are large, containing enough food-

yolk to nourish the embryo until it is hatched in a condition closely resembling that of the parent, except in size and pattern, but large and strong enough to look after itself. In

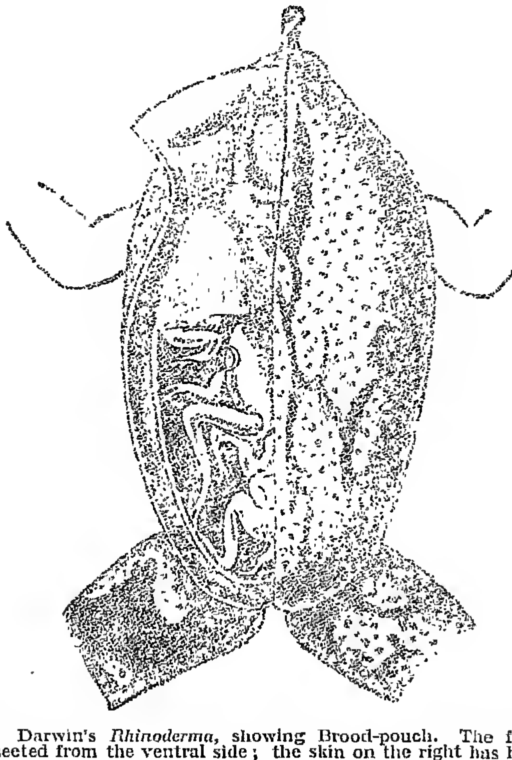


FIG. 27. Darwin's *Rhinoderma*, showing Brood-pouch. The frog has been dissected from the ventral side; the skin on the right has been cut away, showing the opening from the mouth to the pouch, the posterior half of which has been opened to show the young frogs. (*After* HOWES; enlarged.

consequence of this, the old larval stages are suppressed, and although the embryo passes through a phase when it has gill slits and the appearance of an aquatic creature, this takes

place before hatching, and the young are terrestrial. Even the aquatic reptiles come on land to breed, and there are no more than vague reminiscences of their gill-breathing ancestors. The eggs are enclosed in a firm shell, sometimes tough and leathery, sometimes hard and brittle, but nearly always white in colour. In most cases, the eggs are hatched outside the body, but in a few snakes and lizards they are retained until the young are born, in these cases the shells being very thin. Brood-care is almost completely confined to a choice of the place in which the eggs are to be laid, and the formation of a nest or burrow to contain them. The females alone perform this duty, and although in certain cases the mothers exercise some guardianship over the young after birth or hatching, the males take no interest in them.

All the turtles and tortoises lay white eggs with a stout shell, which may be thick and hard, or leathery. The females usually make a hole in the ground, in some well-chosen locality, to which they return year after year, and are at the pains to cover up the eggs and so far as possible remove all trace of their presence—a necessary precaution, as they are a favourite food of many different kinds of animals. The female common European pond-tortoise selects a piece of hard bare ground, which she moistens, and then bores a hole in it with her tail, afterwards enlarging the cavity with her hind limbs until it is several inches deep. The eggs are placed in this and then the hole is filled up with earth and firmly stamped down so as to leave no trace of the disturbance. The female of the common Greek tortoise, which is often kept as a pet, lays from two to four eggs rather late in summer, and buries them carefully in the ground. Soon after the young emerge they bury themselves, and do not reappear until next spring.

In crocodiles and alligators brood-care is farther advanced. The eggs are large, oval and hard-shelled and are laid in a carefully selected or prepared place, out of the water, and both the eggs and the young are frequently savagely protected by the mother. The Indian gharial digs a nest in the dry sand, arranging the eggs in layers and carefully covering

them. The Nilotic crocodile makes a circular nest in the sand about two feet deep, with a raised floor and undercut walls, so that the eggs when they are laid roll from the centre under the protection of the wall. The first layer is covered with sand and a second layer then added, and the whole covered up. The mother remains on the nest to guard it, returning to it after her visits to the water in search of food When the young are nearly ready to hatch, they make a barking noise inside the shell; this is said to attract the attention of the mother and to bring her back to the nest. She takes the young to the water when they have hatched and guards them against their many enemies for a considerable time.

The young of all the alligators and crocodiles are hatched in a lively and vigorous condition, and are able to snap rather savagely almost before they leave the shell. I have personal experience only of young alligators. These are very easily tamed, and quickly learn to distinguish between persons, taking dislikes to individuals and always snapping at them and refusing to be handled, whilst with others they are gentle and docile. They make a loud barking noise to attract attention. It is known that the mothers protect the young in the case of some species of crocodiles, and I am inclined to think that this happens in most of the species. In any case the newly hatched young remain together for a time, and tolerate each other's presence. Healthy crocodiles and alligators, young or old, are rather savage creatures, when the water in which they are kept is not so cold that they are torpid. They are ready to snap at any moving object, or even at a piece of wood thrown into their pool. And yet, although there are occasional accidents, they are gregarious, seldom attacking one another savagely unless in an actual struggle for food. Individuals of all sizes and of several kinds may be kept safely together. This instinct of toleration for their own kind is, no doubt, the result of the association of the young with each other and with the mother. The voice is certainly used as a recognition call. The strong musky odour, due to a secretion from glands at the root of the tail, but which pervades the whole body, may possibly also serve for recogni-

tion, but I have never been able to detect the odour in young animals.

Lizards lay relatively large eggs, the numbers varying from two to twenty or thirty. The process of incubation takes a long time, and when the young creatures emerge they are fully formed, differing from their parents only in size and colour. They are usually white, or very pale, and lie quietly for a few days, and then set about the business of life without any assistance or guardianship from their parents. Little trouble is taken even about the deposition of the eggs. They are usually placed in holes on the ground, in heaps of leaves, or in any natural cavities. A certain number are viviparous—that is to say, the eggs hatch just before they are laid. The slow-worm, one of the common English lizards (*Lacerta vivipara*), some of the chameleons and many of the skinks are viviparous. Thus although brood-care among lizards is passive, the large size of the eggs and still more the occasional viviparous habit secure that the newly hatched or born creatures are mature enough to be independent, and the number of the family has been reduced.

The eggs of snakes are large, usually very elongated and enclosed in a soft, but tough, shell. They are not very numerous, varying from three or four to fifty. They are fertilised before they leave the body of the mother, but the length of time they are retained seems to vary a good deal even in individuals of the same species, with the result that some eggs when they are laid contain only the merest microscopic trace of the embryo, whilst in others the young snakes may be almost ready to hatch. Snakes, in fact, seem to be on the way to protect the eggs by retaining them in the body until they hatch, and many of them have actually become viviparous. Amongst these are the smooth snake, the common adder, most of the burrowing snakes and many of the sea snakes. In viviparous eggs the shell is extremely thin. The sea snakes are said to protect their young after hatching, but maternal care in most snakes does not go beyond finding a suitable locality for the eggs, which are usually laid in heaps of earth and leaves, in holes, or in manure heaps. The boas and pythons and some of the venomous snakes dispose

the coils of the body round the eggs and lie with them until hatching takes place.

Thus in fishes, batrachians and the different kinds of reptiles, there are to be found all stages in the process by which the number of the family is reduced, and better protection given to the eggs, larvæ and young. Prolificness is replaced by parental care, and although there is little or nothing that can be thought of as education, the instincts of both parents and young are modified by the association in family life.

CHAPTER X

BROOD-CARE IN BIRDS

ALL birds lay eggs protected by a hard shell and containing a quantity of yolk for the nutrition of the embryo. The greater part of the development takes place after the egg has been laid, and is as direct as possible, ancestral larval stages having been suppressed. The eggs themselves and the young chicks are a tasty and nutritious prey for many kind of animals. Some lizards and many snakes are eaters of eggs, whilst young birds are even more favourite victims. These reptiles are keen-sighted, active and lively, and hunt over the ground, searching the best-concealed crannies, penetrating dense thickets and climbing the tallest trees. Nor do birds themselves respect their own kind. In almost every family there are some which will prey on the eggs and young of other birds. Gulls, magpies, ravens, carrion crows, moorhens and brush turkeys are notorious robbers, and will go long distances to ferret out nests and young. Mammals of all kinds are even more serious enemies, and not a few that are usually vegetarian often devour eggs. Rodents, for instance, are habitually feeders on grain, roots, leaves and other vegetable matter. But rats are clever and persistent thieves of eggs, especially of those that are to be found on the ground or in holes, whilst many will ascend bushes or tree stumps in pursuit of their prey. Squirrels have a still greater range of destructiveness, as they will hunt on the ground as well as on the trees, and although for the greater part of the year they are purely vegetarian, in spring they plunder nests. Woodpigeons, thrushes and blackbirds and all the small songsters that build in shrubs and hedges have had their nests pulled to pieces and their eggs and young destroyed. The smaller tree-climbing carnivores, although many of them are vegetarian and frugivorous, cannot refrain from eggs, and the fierce and bloodthirsty stoats, weasels and their allies are

relentless persecutors of birds. Monkeys, and man himself, are still more crafty and diligent in seeking out nests. I do not know any monkey that will refuse an egg, and even the great apes, which are amongst the most vegetarian of the Primates, greedily devour eggs in all stages of incubation, as well as nestlings and young birds. The civilised boy, birds'-nesting in the hedgerows, or scaling tall trees to add to his collection, is pursuing one of the oldest habits of his ancestors.

It is almost a wonder that any eggs hatch into nestlings, any nestlings survive to be fledged, or fledglings reach the relative safety of adult life. And yet the eggs are so cunningly placed, and the young so zealously guarded, that the limitation of the family has reached much farther than in the lower groups. The ostrich, it is true, lays about thirty eggs, but this is an extreme instance. Birds such as pheasants, partridges and other ground birds, which fly badly and are specially exposed to the dangers affecting the young of all birds, may lay as many as twenty eggs. Most of the smaller arboreal birds lay not more than four or five eggs. Pigeons, birds-of-prey and humming-birds usually lay two, and many sea-birds such as petrels, divers and guillemots lay only one. So also most birds breed only once a year, but, if the first brood be destroyed, they may lay a second time.

Brood-care begins with the selection of a suitable place for the deposition of the eggs. Occasionally degraded individuals, if we take the ethical point of view, or unusually intelligent individuals, if we take a view more consonant with human individualism, will make use of the abandoned nest of other birds, or will turn out the occupants of an inhabited nest, and use it for their own purposes, and in some species this has become a habit. The common cuckoo and some other cuckoos carry this parasitic habit farther. The eggs are always deposited by the female in the nests of other birds, and the young cuckoo, when it is hatched, creeps under the nestlings of its foster-parents and by a violent effort raises them one by one on its hollow back and jerks them out of the nests, so securing undivided attention in future.

Some birds are content with very little preparation for the eggs, whilst in others the most elaborately constructed nests

are prepared. The New Zealand kakapo or ground-parrot hides in holes and burrows and lays its eggs there without any preparation. Ostriches have the reptilian habit of digging a hole in the ground, in making which several females combine, and then deposit the eggs and cover them up. Emus scrape a shallow hole in the ground and do not cover the eggs. The cassowary scrapes together a rude pile of leaves and mould on which she lays the eggs. The apteryx lays a single enormous egg, which she hides among fern roots. Most of the auks lay their single egg on a bare ledge of rock, making no preparation for it. Penguins may lay on the bare rock in the huge communal rookeries or breeding-grounds which they frequent, or may scrape together a rude heap of débris. The stone-curlew and the goat-sucker choose a site carefully, returning to it year after year, but make no preparation, laying the egg on the bare ground. Birds belonging to many different groups choose natural cavities, burrows, caves or hollow trees for their eggs, and may either line these with leaves, feathers and other soft materials, or make no further preparation. Not infrequently they use their feet to enlarge the burrows, or even to dig them out. Puffins, for instance, regularly breed in rabbits' burrows, sometimes turning out the rabbits, but enlarge them or make shift to dig holes for themselves. Most of the petrels and a few ducks breed in burrows. The stockdove and the rockdove breed in caves, in clefts in the rock, or in holes in trees. Most of the parrots, as well as kingfishers, hoopoos, owls and woodpeckers, hornbills and sand-martins, dig out holes in wood or sand, or occupy holes already made.

Most of the game-birds, shore-birds, waders and ducks and geese lay on the ground or in low-lying situations, and show every transition from a mere scraping on the rocky shore to an elaborate collection of twigs, leaves, plant refuse of all kinds, making heaps which may be several feet high, whilst some, like the redshank, build a dome of grass over the eggs. Floating nests on rafts of water-weeds or sticks are not uncommon, and there may be little attempt at choice of situation, or the greatest care may be taken in selecting a naturally concealed spot. Some of the megapodes or brush turkeys

bury their eggs in the sand, and take no further trouble, leaving incubation to the chance warmth of the sun. Others build enormous heaps of decaying leaves, the natural fermentation of which forms a hotbed in which incubation takes place, without assistance from the body-heat of the parents.

Although owls select holes in trees or in caves, and line them with some warm material, the diurnal birds-of-prey select open ledges, generally on inaccessible cliffs, and there construct a very simple nest of coarsely entangled material. Twigs and dry branches are collected and roughly intertwined, and may form a great pile containing many hundredweight of materials. The nest of pigeons is a platform of twigs so slight that the eggs are visible from below. Crows and herons build nests which show little more skill. The magpie starts with a similar rude platform, but may surround it with a hedge of thorns, or roof it over with a dome of twigs. A pair of hammerkops or tufted umbres living in the London Zoological Gardens constructed a nest which is a farther advance on that of the magpie. They made a platform of sticks, cemented with mud, and covered it with a huge dome of sticks nearly two feet in height, leaving a small entrance at the side. Some of the finches, as, for instance, the hawfinch, begin with a platform and then place on it a cup woven of hair and rootlets. Thrushes make a cup of rootlets and wool and twigs, supported on a platform of twigs, and then line it with a plaster of mud and cow dung. In the more elaborate nests of many of the small singing birds, the use of mud as a cement is discarded and the whole nest is woven of the finest hairs, vegetable fibres and wool, softened during the process of building by saliva from the mouths of the builders. The most curious and elaborate shapes may be attained, pendulous purses, globes or retorts, or hanging baskets. There may be one or more entrances, and these may be prolonged to form tubes or twisted tunnels, possibly to make access by snakes more difficult. The tailor birds select large pendulous leaves and with their beaks pierce rows of holes along the two edges of the leaf, and then first twist a thread out of spiders' webs, fragments of wool or cotton, and, weaving it in and out of the holes they have made, bring the edges of the leaf together,

transforming it to a hanging purse, within which the nest is built. The ingenuity and diversity of the various woven nests are endless, and allied species show all the stages between rude structures and exquisitely finished houses. There are so many instances of different formation of the nest according to the different environment in which the birds live, and so many cases where it seems plain that the instinct is partly degenerate, that it is impossible to arrange a parallel series between the complexity of the nest and the position of a particular species in its family. Types of construction run through the nests of allied species, but appear in all stages of perfection and degeneration.

When the "nest" is merely a hole scraped in the ground, in most cases it is the work of the female only. When it consists of a quantity of material scraped up, or collected from a distance, or woven or moulded into a specially shaped receptacle, both males and females join in the task. There are a good many cases where birds associate in colonies for nesting. We are all familiar with rookeries, and with the massed nests of swallows and swifts. A great-many sea-birds lay their eggs or construct their simple nests so close to each other that they almost touch, and there are one or two instances where birds combine to form enormous structures containing the individual nests of many pairs. It is probably more the common choice of a suitable site than any social instinct that has led to these associations. Although quarrels and robberies are frequent, there is a certain amount of combination against common enemies, but the families remain really distinct, and there is nothing approaching the ordered communities that occur amongst insects.

When the receptacles are ready, the females place the eggs in them. Eggs differ remarkably in shape. Some are almost spherical, most are elongated ovoids with one end larger than the other, in the extreme cases the eggs being pear-shaped. Rounded and regularly ovoid eggs, if given a push on a smooth surface, will roll a great distance; pear-shaped eggs simply twist round in a circle of which the narrow end is the centre. Such eggs would certainly be little liable to breakage by being rolled off rocky ledges, and they are found

in the case of many birds which lay in dangerous situations, but they also occur in shore-birds where there is no similar danger. There appears to be no advantage or special adaptation in the various gradations from nearly spherical to oblong eggs.

The shell of eggs is a transparent, organic membrane thickened and hardened with deposits of lime, and the natural colour, perhaps the primitive colour, is white as in the case of reptiles. In a very large number of birds belonging to different groups and with different habits the white colour is retained.

The relation of coloured eggs to the environment is difficult to interpret as an intelligible adjustment of conditions to environment. The colours of eggs are all due to pigments which are derived from the blood and find their way to the outer surface of the eggshell through the walls of the oviduct. If a bird with an egg nearly ready to lay is frightened so that it rids itself of its burden before the normal time, the premature egg is frequently paler, or even colourless, and if more than one egg is laid, it frequently happens that those which are deposited first are less brightly marked or coloured than their successors. Many birds lay eggs which are very different in appearance from each other. Guillemots and cuckoos are well-known instances of this, and attempts, in my opinion quite unsatisfactory, have been made to show that the cuckoo chooses nests with eggs corresponding in colour to those which she has laid, as the repositories for her own produce. Many of the birds-of-prey, the secretary bird and some petrels, lay white or very pale eggs with irregular blotches or spots of red, the latter in holes, the former on rude heaps of twigs in the open. The South American ostrich or rhea buries her eggs like her African relative, but they are green or yellow at first and afterwards fade to a dirty white. The cassowary and the emu deposit on open nests eggs which are evenly coloured with bright or dark green. Tinamous lay, on the bare ground, highly polished and lustrous eggs, self-coloured with vivid shades which differ remarkably in the different species, chocolate, purple, blue, blue-green or primrose. Turacos lay green eggs on an open platform, the

hoopoos green eggs in holes, and the bustards greenish eggs with reddish blotches in rude nests on the ground. Some ibises and spoonbills lay blue eggs in nests on trees. There is rather more uniformity in the case of spotted and blotched eggs, which in many cases are laid on the open ground aud may gain some protection from their resemblance with pebbles, a protection which is most efficient in shore-birds. The latter, most of the gulls, coursers, nightjars, cranes and button-quails lay spotted or blotched eggs on the ground, often with the merest scrape in the sand to serve as preparation. Similar eggs are laid by auks in holes or on ledges, by cariamas on the ground, in bushes or on trees, by divers on masses of grass and herbage piled up near the edge of the water, by sun-bitterns on a platform, and by hoatzins on tall trees. Finally, amongst passerine birds almost every kind of egg, white, evenly tinted with some bright colour, spotted or blotched, is to be found, and he would be ingenious indeed who could arrange them in a system coherent with their environment.

We have to remember that the existing colours and patterns of eggs and of animals may be survivals from circumstances in which they were useful. Animals, even in recent times, have spread from one country to another, have been driven or have migrated from the hills to the plains, from the jungle and forest to barren open country. They have changed their habits from choice or from necessity. Birds of the same species often nest under different circumstances in very different places, sometimes in holes, sometimes on the ground and sometimes on trees. Closely allied species in many cases show great differences in their choice of nesting-places and in the nature of the preparation they make. Habits and surroundings may thus change very quickly, much more quickly than we can suppose structure and function to change, and colours and patterns that had fitted a former environment may seem strange and unsuitable in a new environment. No doubt if they were very unsuitable, the old colours and patterns might lead to the extermination of their owners, before they could be changed. But equally possibly the advantages of the new habit or new surroundings might

be so great that they would counterbalance the garb that had lost its suitability. Birds are a highly successful branch of the animal kingdom, with great powers of locomotion and with great capacities for adapting themselves to new circumstances, and we might well expect to find amongst them many cases where coloration had outlived the conditions to which it was suited.

When the eggs have been laid, they have to be kept warm until they hatch, a duty that is avoided only in a few rare cases. Birds are even more hot-blooded than mammals; it is not always easy to take their temperature accurately, as the act of handling them excites them and raises the temperature, but it seems to range from the human normal to about 104° or 105° Fahr. The eggs must be kept at temperatures approaching or surpassing these for the whole period of incubation, although cooling for a short time, such as happens when the brooding bird leaves the nest to feed, does no harm, and is even imitated by those who are most successful in using artificial incubators. The time required varies from about ten days (in some of the small singing birds) to about six weeks or two months (ostrich). On the whole it is rather shorter in small birds than in large birds, at least within the same families. Thus the small ducks require about three weeks, geese about a month and swans about forty days. Comparing groups with groups, there is much difference which is not easy to explain, but the most general arrangement is that when the eggs are small, containing little food-yolk, and the young are hatched in an imperfect condition, the period of incubation is short, as, for instance, amongst passerine birds, and where the eggs are relatively large, containing much food-yolk, and the young are hatched in a more advanced state of development, the period occupied is longer.

All the megapodes or brush turkeys have given up brooding the eggs. Some of them lay in the warm sand, others are said to select the neighbourhood of hot springs, whilst others again, like the brush turkeys most familiar in captivity, make huge mounds of vegetable matter, the fermentation of which supplies the necessary heat.

In some cases the male bird performs the whole duty of

incubation. This happens in the cassowary, rhea, tinamous, phalaropes and painted snipe, and it is amongst these that the curious cases occur in which the males are more dully coloured than the females. In many birds both sexes share the duty. The cock ostrich watches over the hole in which the eggs have been buried, by night, whilst the hen takes up the duty by day. The screamers work in shifts of two or three hours each. When they bred in the London Zoological Gardens, it was noticed that the cock bird acted as time-keeper, and at the end of a watch used to come and push the female off the nest. The emperor and king penguins lay their single eggs on the bare ground, often in extremely inclement weather when there are heavy storms of snow and severe frost. Each egg is brooded on the flat feet of the bird, and a warm flap of skin and feathers, specially enlarged during the breeding season, hangs down from the abdomen and covers it like a blanket. From time to time the male and female relieve one another, and this is done with a quaint ceremony of bowing, and with a careful scrutiny of the egg before it is handed over. Large numbers of eggs are destroyed by the weather, and so great is the desire of these birds to brood that they will steal an egg for this purpose. Probably the eggs are changed so often that family rearing has been replaced by communism. In the sand-grouse and the bustards both parents share in incubation, but in the great majority of the higher types the female alone does the work.

When the female only broods over the eggs, the male may take no interest in the proceedings, or may remain as a guardian of the nest and hen, or may assiduously feed her. As soon as the female duck begins to sit, the drake flies off and does not reappear until the young are nearly fledged. In gulls, most of the birds-of-prey, swans, storks and rails the male keeps near the nest, and savagely attacks any intruders. In Montagu's harrier and some other birds-of-prey, the cock brings food to the hen, whilst it is almost the rule amongst singing birds for the male to remain with the female and assist in feeding her. The hornbill, which walls up the female in the trunk of a tree during the breeding season, feeds her most diligently, and indeed she would otherwise starve.

All birds during incubation take a great deal of trouble with the eggs, often turning and rearranging them, sometimes covering them up when they leave them, and often bringing fresh material to add to the nest. It is quite certain that sometimes because they have been disturbed, possibly when some of the eggs have been taken, and sometimes for no apparent reason, they get dissatisfied with the nest, become suspicious and desert it. If a nest be disturbed before its construction is completed, the birds generally leave it and begin a new one somewhere near. When the eggs have been laid, what usually happens, if a disturbance has taken place, is that the nest is deserted, and if it is sufficiently early in the season, a new set of eggs is laid in the new nest. Even when the young have been hatched, desertion is the usual result when the parent has been disturbed or annoyed. In similar cases amongst mammals, the mothers, even although they are not naturally carnivorous, will kill and eat their own young.

Brood-care of another kind begins when the eggs hatch out, and its nature depends partly on the condition of the young chicks. There can be no doubt but that birds are modified reptiles, and most probably ancestral birds, like living reptiles, hatched out in a condition in which they were active and very closely resembled their parents. If they were unable actually to fly, they at least could run about actively, and make fluttering or gliding and parachute-like motions with their wings The megapodes are the only living birds that are hatched in such a stage that they are able to fly at once, and in which parental care ceases with the laying of the eggs in a suitable place. It is improbable, however, that these represent an actually primitive condition that has survived. They pass through a moult before they are hatched and it is very likely that their extreme precocity is a comparatively recent acquisition. If we count, not by species, but by orders, sub-orders and really well-separated families, then by far the greatest number of different kinds of birds are hatched in a stage in which, although they are not able to fly, they are alert, active, able to see and to pick up their own food, and all these are clad from the first in a coat of down.

Next, there is a smaller assemblage of birds in which the young are helpless when they are hatched, but are covered with a coat of down. Most of these are rather large or powerful and ferocious birds, well able to defend their young. Lastly, there is a group in which the young are hatched naked and helpless. The pigeons and herons almost might be placed here, and the group includes some like gannets, cormorants, and pelicans and parrots, in which down is very soon developed, and many in which there are slight traces of down, but on the whole they are practically downless. The most general statement to be made about this last group is that it contains those birds which most anatomists would recognise as being the highest or most bird-like birds.

There has taken place amongst birds, or rather I might say there is taking place amongst birds, a change from a condition in which the newly hatched young can very quickly look after themselves, to a condition in which the young are absolutely dependent on their parents for some time after they are hatched. The older, more reptilian condition in which the young were provided for by a merely material sacrifice on the part of the mother, by storing a large quantity of yolk in the egg, is being replaced by a condition in which the self-seeking instincts of the parents are temporarily changed into instincts and habits where the main object of life is not self-interest, but the satisfying of the needs of others.

Even when the newly hatched young are fairly active and soon able to feed themselves, one or both parents guard and protect them for a considerable time. They exchange call-notes and when danger comes near, the young hasten to shelter under the wings of their parent or squat down whilst she attempts to lure away the intruder, sometimes, like the plover or the partridge, pretending to have a broken limb or to be lame, and so diverting attention to herself, sometimes, as in the case of the hens of fowls and pheasants, or by the cocks and hens in gulls, attacking the supposed enemy savagely. A few birds carry their young about. The woodcock holds them between her legs, partly supporting them by her beak, when she flies from one feeding-ground to another. Grebes carry the young on the back as they swim through the water,

and every one must have seen cygnets taking refuge on the back of the male or female swan, nestling under their wings as they swim.

When the young are helpless, the parental care and protection are even greater. Birds which are naturally timid will fly out and strike savagely at disturbers of their nests and young, whilst those that are strong and predatory are extremely dangerous to approach when they are with eggs and young. Most of them take great trouble with the sanitation of the nest or of the breeding-hole, first themselves carrying away the droppings of the young birds, and afterwards encouraging the nestlings to void their excretions over the edge of the nest. There are a few birds, such as hoopoos and kingfishers, which take no trouble in these matters, but the nests and the bodies of most young birds are kept scrupulously clean.

Finally, in all cases where the young are helpless, and in a good many where they are active, one or both parents work assiduously in feeding them. Whatever be the natural diet of the adults, the food of the young is almost always animal matter. There are of course some exceptions. Ostriches, almost as soon as they are hatched, begin to crop green herbage for themselves, although cassowaries, emus and rheas require food such as insects and spiders. The secret of rearing ducklings of almost every kind is to supply them abundantly with the common duckweed of ponds, and although there is usually a rich microscopic animal life adherent to these plants, the bulk of the food is vegetable. But all the soft-billed birds, which are naturally insectivorous, most of the fruit-eaters and practically all the hard-billed seed-eaters work from dawn to dark searching for grubs, caterpillars, maggots, worms and all manner of creeping and flying things to feed their hungry young. Other birds hawk insects on the wing for the same purpose, and those who resent the occasional devastations of their fruit-gardens and seed-beds should remember that human life would be almost intolerable, and the toil of the gardener and farmer almost futile, were it not for the destruction of insects and their larvæ which is the work of birds engaged in feeding their young.

Many birds feed their young on food which they have partly digested and thrown up. Some of the finches, which at first bring insects to their young, afterwards feed them on partly digested food. Parrots also digest their vegetable food and supply it to the young in this condition, whilst some woodpeckers, martins and others throw up digested insects. Storks break up frogs, worms, pieces of fish or flesh, mix it with partly digested matter and throw it on the edge of the nest for their young. Petrels secrete a kind of oil from the fish on which they live, and discharge it by their beaks into the mouths of their young. Little cormorants thrust their bills down the short straight throat of their mothers and help themselves from her stomach; whilst young pelicans take fish from the mother's enormous pouch-like bill. Young pigeons obtain their food by thrusting their beaks into the mouth of the mother and absorbing the so-called pigeons' milk, which is partly digested food and partly a secretion from the crop. Whatever method be adopted, the feeding of the young may go on until these are nearly as large as the parents.

Young birds, especially those that are born naked, are extremely sensitive to cold, their temperature rising and falling with that of the surrounding air, just as happens with reptiles, and no small part of the duty of the parents is to keep them warm. This is generally the work of the mother, and for some days, in the case of the smaller singing birds, she hardly leaves the nest, the male during this time doing all the work of foraging. In four or five days the little birds have found their feet and are able to move about in the nest, and then the mother is able to leave them for a longer interval, and to take up her share of collecting food.

And so in nearly all birds, from the choice of the place for the eggs, through the long duty of incubation, and for a longer or shorter period after the young are hatched, one or both of the parents are fully occupied with parental duties. The final period of brood-care lasts for periods varying from three weeks to several months. Then suddenly it comes to an end. The parents resume their natural devotion to their own personal wants, and even those that have been most assiduous and most devoted now quite suddenly either fly to

new haunts, leaving their offspring behind, or drive the fledglings away from them. The abandoned young often consort until they have reached sexual maturity, when new instincts awaken and the battles for mates begin.

If the time occupied in building the nest, in incubation and in looking after the young be added, and if it be remembered that most birds breed at least once a year, and those which get over their duties quickly often breed twice a year, we reach the conclusion that a large part of the time of adult birds is occupied with parental care. This increased care has made it possible for the number in the family to be very greatly diminished.

CHAPTER XI

BROOD-CARE AMONG MAMMALS

MAMMALS are not only the highest group of the animal kingdom, but one of the latest products of evolution. At a time which is not very remote in geological history, a set of reptiles slowly assumed the mammalian characters, and there is no reason to doubt but that these ancestral reptilian-mammals laid large eggs like living reptiles. Some of the living reptiles, like some living fishes, retain the eggs in the body until they are almost ready to hatch, and so secure for them warmth and protection much more certainly than in the most cunningly devised nest. Some reptiles even keep the eggs in the body until they hatch. It is most easy to understand what now happens in mammals if we suppose that their reptilian ancestors had acquired this habit of egg retention. The lowest living mammals, the duck-billed mole and the spiny anteater of Australia, still lay rather large eggs, but retain them in the body until they are nearly ready to hatch. The marsupials and all the higher mammals not only retain the eggs in the body but change the way of feeding the embryo in a fashion that is foreshadowed even in some fishes. In ordinary large eggs which contain enough food stored up as yolk to nourish the young until it is hatched, the blood-vessels of the growing embryo spread out over the yolk just under the eggshell and absorb oxygen from the air through the shell as well as food from the yolk inside the shell. When such an egg lies in contact with the wall of the egg-duct of the mother, the supply of oxygen for the embryo must be picked up from the blood of the mother. This has led to two changes. In the first place, the embryo picks up from the blood of the mother not only oxygen but the food it requires, so that the yolk is no longer necessary; and in the second place the eggshell becomes thin, soft and membranous so that the connection between the blood of the mother and

of the embryo becomes closer. Most of the marsupials have remained in this stage. They have eggs that are smaller in proportion than those of reptiles or than those of the lowest mammals, but much larger and containing more food than those of the higher mammals. In the latter there is practically no food-yolk at all, and the eggs are microscopic in size, being just visible to the naked eye. They soon develop a connection with the maternal tissues which is a legacy from the blood-vessels which spread out under the shell, and then replace that by a new and more perfect means of drawing nutriment from the blood of the mother, the structure which is known as the placenta.

In mammals, therefore, the earliest stages of brood-care, instead of being apparently conscious, external acts, which, so to say, might be slurred over, bungled or forgotten, have become a part of the unconscious mechanism of the body. Instead of having to construct a safe place in which to lay eggs, the mother retains them in the interior of her body, supplies them with the necessary warmth and food, and protects them from enemies at the peril of her own life. This change from external to internal protection is least complete in the egg-laying mammals, more complete in the kangaroos (where the young are born when they are very small and placed in an external pouch by the mother), and most complete in the higher mammals. Just as there are some birds hatched when they are ready to run about and others hatched when they are still blind and feeble, so there are some mammals where the young are born almost ready to walk or to run, and others where they are born blind and naked, differences which depend on the habits of the animals and may be found amongst species that are very closely allied.

This internal organic brood-care is just as effective in protecting the young as the brooding of birds, and it is followed by a still longer period in which the new-born mammals are fed and guarded by the mother. And so it happens that amongst mammals brood-care is more elaborate and complete than in any of the other groups of the animal kingdom. The young do not leave their parents until they are well equipped to fight the battle of life for themselves. The maintenance

of the species by the production of enormous families has ceased. Some of the little rodents may breed several times in the course of the year and produce rather large litters, and there are some fecund mammals, such as pigs, where the litter may contain a dozen or even more. But these are rare exceptions In the vast majority of cases, mammals breed no more than once a year, and in some instances only once in every two or three years The usual numbers are one, two or three at a birth, and the higher in the scale of mammalian life one looks, the smaller is the number that is usual.

The preparation for the birth of the young is seldom a serious matter amongst mammals Those which have not natural homes, and a good many of the others, do not seem to be aware of the approaching event almost until the actual birth begins, and merely follow the natural instinct of animals that do not feel quite well. They retire from their companions and seek a sheltered place. Nothing is known as to birth in the case of the man-like apes in the wild state Baboons, cercopitheques, langurs, macaques and many of the small American monkeys have bred in captivity The female which is about to be a mother generally shows an enlargement of the breasts and a slight restlessness for a day or two before the actual birth; sometimes she ceases to take food and retires into her shelter or sleeping-box, to appear again with her infant.

Lemurs often breed in captivity and are extremely good mothers. As in man and true monkeys, there is usually only one at a birth. It clings firmly to the mother, lying horizontally across the lower part of her abdomen, holding on by its hands and feet and with its long tail twisted round the back of the mother. The mother, however, helps to support the baby by her own tail, which she usually curls up between her legs over the body of the infant and then twists round her own body. Later on, when the young is more active, it is often carried on the back of the mother. For the first day or two the mother sits upright with the baby lying across her abdomen, and bends over it from time with a low crooning noise. Male lemurs take no interest in their young and have no share in protecting them. The text-figure (Fig. 28) shows

FIG. 28. Ring-tailed Lemur carrying its young. (After POCOCK.)

the young of a ring-tailed lemur being carried on the mother's back.

In all the carnivores the young are born in a helpless condition, usually blind, although new-born lions can see, and remain with the mother, sometimes with both parents, for a period ranging from a few weeks in some of the smaller

creatures to even more than a year. The large predaceous creatures cover great distances in pursuit of their prey, but usually have permanent headquarters which they use by day if they are nocturnal, or at night if they hunt by day. The lair is in a well-concealed place, capable of defence, in the middle of a thick forest-brake, or in dense reeds, or in a rocky recess in the side of a hill, or in a hole, burrow or hollow tree. In captivity, the mothers always retreat to the darkest corner of their enclosure to bring forth their young, and one of the necessities for successful breeding is to provide a suitable shelter for this purpose. It is often useful to provide two, for the mother, even if she be not disturbed, is restless after the cubs are born, and frequently will carry them from one place to another until she finds a nook to her liking. It is in the first few days that the young run the greatest risk of being eaten by the mother. A bed of soft dry earth, of leaves or litter, is frequently scraped up beforehand. When pumas live in a place where there are not natural caves or rocky recesses they make a lair of twigs and moss in some dense thicket, with an overarching roof of evergreen canes. The early days of all carnivores are spent in a nursery of this kind, and the mother takes scrupulous care to keep it sweet and clean, whilst she licks the cubs with her rough tongue until they are able to look after their own toilet or to lick and clean each other.

The duties of parental care among carnivores fall chiefly on the mothers, and although lions and tigers and not a few of the larger cats remain in pairs, the father takes little interest in the cubs. For the first few days the mother does not leave her family even to feed, but afterwards she has to leave them from time to time to go out hunting on her own account. Almost the first sign of independent life in young carnivores is their power of wailing and screaming; they are very noisy babies, and in captivity, when cubs are expected and the mother has retired to her sleeping-den, her guardians know when the happy event has taken place by hearing the squealing of the cubs. Polar bear cubs have loud, shrill voices and seem to cry almost continuously from the moment they are born. Lion and tiger cubs, leopard and jaguar cubs, have

thinner and smaller voices at first, but in a few weeks wail like cats. The voice of a caracal cub, when it is so young that it cannot yet stand upright, can be heard all over a house if the little creature has been shut up alone. Hunger is certainly not the chief reason why they cry out, for they are as vehement after a good meal as before it. Cold is sometimes the cause of the complaint, because all young carnivores like to be kept very warm, and will bask with comfort in front of a fire until their fur feels hot to the touch. What they want is companionship, and their loud shrieks when they are left alone guide the mother to them, and she in return calls to them with a special note unlike her usual purr or roar. Many carnivores, as, for instance, pumas and caracals, practically never use their voices except in the breeding season, and then chiefly as a call between the mother and the young.

The carnivorous mother always carries her young about in her mouth, picking them up by the loose skin on the back of the neck, and so carries them back to the lair if they have wandered from it, or transports them to new quarters. Although the cubs or kittens climb over the mother when she is lying down, she seldom carries them except in her mouth. A polar bear in the London Zoological Gardens, however, was noticed to carry her cub, not in her mouth, but tucked under her arm. Raccoons carry their young on their backs, and it is probable that some of other carnivores that live in trees have similar habits.

Before they are weaned, young carnivores begin to scrape off fragments of flesh from the prey that the mother has brought home and so gradually acquire a taste for their future food. Before they leave the lair they are taught the elements of stalking by the mother, who lets them play with her tail, flicking about its tip, and training them to seize hold of it and worry it. As soon as they are strong enough they are taken out by the mother, sometimes by both parents, on foraging expeditions. Family parties of lions have often been seen by African hunters. It seems that it takes nearly a year and a half for young lions to learn the business of stalking. At first they go out with the parents on short excursions and

wait behind until the kill has been made, when they rush in and follow the example of the parents in tearing the prey to pieces. During this time lions frequently prefer an easy prey, attacking flocks of sheep or goats and killing more than they require for food. After the first year, when the canine teeth are powerful, the young lions are allowed to stalk and kill their own prey, but the parents watch close at hand, to be ready with assistance if necessary. The young animals at first do their work in a blundering fashion, and their kill can be recognised by the clumsy way in which it is mauled. Pumas go out hunting with the mother when they are only a few weeks old. Polar bears teach their cubs to fish and to swim. The smaller carnivores all have the same kind of early training. Young badgers can often be seen playing with their mother at the edge of their "earth" when they are only three weeks old. Later on they go out with her, trotting along in single file behind her in the hedgerows and learning where to find what is good to eat and how to catch it. Polecats, ferrets and weasels bring back small creatures such as mice for their young to worry and eat, and later on take them out hunting.

Many of the animals which belong to the group of carnivores are not really carnivores, but live on fruits, shoots, seeds and other vegetable matter, and they also learn from their mothers how to obtain food. That, however, is a less difficult business, and it is the true hunters of living things that have most to learn. No animal likes being caught and eaten, and the natural victims of the carnivores have learnt intense wariness. They have acute senses of smell and of hearing, and meet the cunning and strength of their enemies with swiftness and prudence. The young carnivores have to learn to stalk them against the wind, to lie in wait for them at their drinking-places, to make the right springs at the right time, and to strike the right blow with claws or teeth. And whilst they are learning these things from their parents, and coming to a knowledge of their own weapons, they have also to learn to distinguish between friend and prey, to use their teeth and claws, roughly no doubt but only playfully, with their brothers and sisters and parents, and to reserve the full strength of

these for creatures they wish to kill. It would be a shorter and simpler business if they had to develop only their instincts of ferocity, to learn to use their natural powers only for deadly purposes. But they have the double lesson to learn and they do learn it. Certainly, carnivorous animals will engage in fierce contests, especially from motives of rivalry or jealousy, but in this they do not differ from other animals which are not naturally predatory. As a group they are not the most difficult to put together or to keep together, and, except for an occasional quarrel over food or over a mate, even the fiercest carnivores associate in peace, and are naturally friendly rather than quarrelsome both with one another and with human beings, or even allied species.

The early life of ruminants is extremely different from that of young carnivores. In the first place they are wanderers. They have to travel long distances in search of water; they must migrate from place to place to find the great bulk of vegetation, of young foliage or herbage that they require as food. Even the large and swift giraffe whose size protects it from all but the most powerful of the carnivores, the strong and savage buffaloes which not infrequently repulse tigers successfully, the agile goats and mountain antelopes which seek safety on the high pinnacles of rocks, and still more the small and defenceless gazelles and brockets, keep alive only by incessant watchfulness and by swift flight from their enemies. They have no permanent home, but from day to day, from hour to hour, almost from minute to minute they must be ready to rush off. Their habit of rumination is itself an adaptation to this shifting life. They do not chew their food as they crop it, but as quickly as may be fill their huge paunches with a great load of green vegetation, and then fly to a more sheltered place to lie down and chew the cud. The mothers make no preparation beforehand for their young, but retire for a few minutes to a thicket and then drop the calves or lambs. One is the most usual number at a birth, and twins or triplets are almost as rare as amongst human beings. The young are born clothed with hair, with their eyes open and their senses alert, and in a very short time, almost as soon as the mother has licked them, are able to

follow her. She then rejoins the herd if the animals are gregarious. The mothers, however, are very devoted to their young, and if there is a herd the bulls will combine in defence of the cows with their calves, whilst in other cases there is usually a family party consisting of the bull, one or two cows and their calves.

A new-born giraffe is able to stand up in about twenty minutes, and to run freely in a day or two; in three weeks it begins to nibble herbage and in four months to chew the cud. So also all young ruminants begin to chew the cud only some weeks after birth, and the young, during the earlier part of their life, resemble their non-ruminating ancestors. Deer are rather feebler than most of the ruminants at birth. Very often they have to be helped up by the mother, and usually lie for two or three days in a thicket before they are able to follow the parent. Wild cattle, sheep and goats are able to move actively in a good deal less time than deer, and chamois and antelopes are extremely active almost at once, beginning to play and being able to follow the mother when they are a few hours old. Young camels are active and playful and can move about almost at once. They begin to eat in a few weeks, but suckle for nearly a year.

The Even-toed Ungulates that do not ruminate, the pigs, peccaries and hippopotami, differ a good deal in their habits from the ruminants. They are less disposed to seek safety in flight, the swine and peccaries being well capable of defending themselves against most enemies, and the hippopotami having few enemies to fear in the rivers they inhabit. Wild swine and peccaries usually produce their young in a dark and secret den, in the recesses of a cave, in deep brushwood, or even in the hollow of a huge tree trunk. The families are rather large, a litter usually containing from four to a dozen, but the smaller numbers are more frequent in wild animals than in the domesticated races. The little pigs are feeble at birth and are sedulously guarded by the mother in her lair for about a fortnight, after which they follow her abroad on her foraging expeditions, but are carefully watched by her for many months. The hippopotamus brings forth her young in a reedy thicket, generally on an island. One is the usual

number, and the baby is active from the first and is able to swim before it can walk. In captivity a hippopotamus has been born actually in the water on more than one occasion, and the mother has usually shown herself rather indifferent, whilst the father takes no notice at all of the young one. In the wild state, however, the young one stays with the mother for a long time, probably for several years, and is carried on her back in the water. African travellers have described the sudden apparition of a small hippopotamus above the water, rising up until it appeared to be standing on the surface, but really being carried on the mother's back

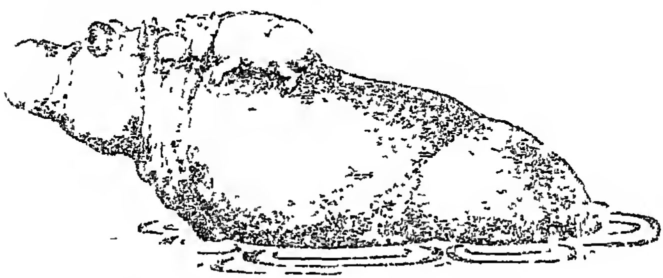


FIG. 29. Hippopotamus carrying its young.

(Fig. 29). When the female reaches the bank, the little one slips off and follows her on foot.

The Odd-toed Ungulates—the horses, asses and zebras, and the tapirs and rhinoceroses—give birth almost invariably to a single young one without having made any preparation beforehand. Foals can see and stand in a few minutes after their birth, and, although they are feeble on their legs, can very soon follow the mother. In the wild condition these animals live in herds, and the stallions combine to protect the mares and foals when they are attacked by lions or wolves, but as they prefer to seek safety in flight, and as the herd has to move about in search of food, the foals must be active very soon. Tapirs are often born in captivity, and, like horses, are active in a few minutes. Extremely little is

known about the breeding habits of rhinoceroses, but the young are plump, strong and active and follow the mother for a very long time, for individuals nearly full grown and certainly six or seven years old have been found running with the mother and still suckling.

Elephants are much more active creatures than is easy to suppose from watching their sedate and leisurely gait in captivity. They travel enormous distances, moving very quickly and climbing almost precipitous mountain slopes with skill, lightness and agility. A single calf is produced at a birth and is able to move and follow the mother almost at once. The mother is devoted, incessantly stroking the young with her trunk, and defending it rather savagely from any rash intruder. The baby suckles with its mouth in the ordinary fashion of a young mammal, and does not use its trunk for drinking or even for picking up food for some weeks. The calf remains with the mother for several years until it is very well grown.

The dassies, rock-rabbits or hyraxes, although they differ extremely in size from elephants, are probably as nearly related to them as to any other living mammals. They live in rocks or in tall forest trees and the mothers usually have a family of three. The young hyraxes are about as big as rats and are thickly covered with very dark hair. They are active from the first and are carried by the mother on her back (Fig. 30). Although they are often compared with rabbits, they are quite different in habit and disposition, being extremely intelligent and affectionate and most plucky and well capable of defending themselves. My young tree-hyrax was once introduced by accident to a palm-civet, which, although tame, was accustomed to try its teeth on everything and was a good many times the size and weight of my little animal. The hyrax, however, at once raised its hair almost like the spines on a porcupine, opened its white dorsal patch and rushed in at the civet with a loud shriek of challenge, gave it a sharp bite, and then quickly sprang back a foot or two, and stood bristling and alert ready for a second charge. This was unnecessary, as the civet was routed and fled shrieking to its owner.

Fig. 30. Tree-hyrax carrying its young

The flesh-eating carnivores and the herbivorous ungulates form two of the most important and strongly contrasted groups of mammals. The contrast is specially evident in the case of the young. The baby carnivores are helpless at first and are produced in well-hidden lairs. For some time they depend entirely on the devotion of their parents and are

fed, protected and trained by them. When they are quite small they are often carried about by the mothers, usually in her mouth, but in a few rare cases in another fashion, by polar bears under the arm, by raccoons on the back. In their young days, when the mother goes hunting she has to leave the cubs behind, and if they wander, discovers them chiefly by the voice. It is only when they are weeks or months old that they begin to follow her Young ungulates have to follow the mothers almost from the first; it is only in a few rare cases, such as the pigs, that they are kept for any time in a lair. It is still rarer for them to be carried by the mother; the hippopotamus and the hyrax are very unusual in this respect, and the former has habits different from those of all other ungulates, whilst the latter belongs to a peculiar and isolated group. Young ungulates, like all mammals, are suckled by the mothers, but are not fed by her in any other way. Certainly parental affection is strong, but it is the business of the young one to find, follow and stick to the mother rather than for the mother, as amongst carnivores, to take the initiative. And the most important difference of all is that whilst no doubt the young find the feeding-grounds by following the mother, there is practically no real training of the young by their parents.

The Insectivora are the living survivors of a very ancient type of mammal, certainly older than the carnivores, and perhaps representing their ancestors. Most of them are small and shy creatures, lurking by day in holes or burrows and coming out at night in search of worms and beetles. The family is generally small, four or five at most, and is born in a helpless condition, frequently blind and nearly naked. The female hedgehog prepares a nest of moss and leaves, placed so that it is sheltered from the rain, and the naked young are too helpless even to roll themselves up at first. In a week or two they begin to play, the spines harden, and the mother teaches them their future diet by bringing worms and beetles to them. The female shrew constructs a globular nest at the end of a blind burrow and lines it with soft hair and leaves. So also the mole selects a spot where two of its burrows meet, and constructs a globular chamber, very

different from the elaborate fortress which is its usual home, to serve as a nursery for the helpless young.

The members of the huge group of rodents vary in size from the South American capybara, which may reach four feet in length, to the pigmy fieldmouse, the smallest of living mammals, and although they are all gnawing, chiefly vegetarian creatures, differ much in habits. Amongst them are the most prolific of mammals, but the rapid rate of multiplication is achieved by the shortening of the period of youth, and by the early age at which individuals begin to breed, rather than by the size of the broods. In many cases there are only two, three or four born at a time, although there are some cases where the number may reach ten or a dozen. In most rodents the young are born naked, blind and helpless, and the young depend on the mother until they are nearly full grown.

In most rodents brood-care begins before the young are born, and the mother selects and prepares a nursery for her family. Rabbits live in communities, and the burrows of a warren form a complicated set of underground passages which lead into each other and are used in common. The females, however, dig out circular chambers opening off the main burrows, generally with two or three exits. These they line with leaves, soft grass, and masses of fur plucked from their own breasts, and the blind and naked young are guarded for some weeks in these warm recesses. Squirrels construct winter nests in the forks of branches and store provisions against hard times. In early summer they build more open nests far out on slender branches and there the blind and naked young are cherished and protected for many months. All the rats and mice make most comfortable nurseries for the young, collecting quantities of soft materials, such as wool, rags, moss, paper, hair or feathers, and arranging them in a burrow or hole. The harvest-mouse weaves a nest which can be compared only with some of the most elaborate habitations constructed by birds. It is made of narrow grasses, woven carefully into a globe about the size of a cricket ball, and is suspended to stout herbs or blades of corn. The walls are very thin, and there is no special opening, the mother squeez-

ing out or in through the meshes. The family is rather large, seven or eight being the usual number, and these lie tightly packed inside the meshes of the nest. Dormice make a nest of the same kind, but generally oval rather than globular, and suspended high up in a thick hedge.

The elaborate dams which beavers make by cutting down trees, collecting twigs and plastering over the tangled mass with mud, keep the water at a constant level, and in the pools thus formed the carefully built lodges are constructed. These always have an entrance under the water and at least one on land. Small branches are fastened to the dam and stored in the lodge, and in winter when food is scarce the beavers take these above water and strip off the bark and eat it. The special chambers in which the young are born are lined with chips of wood quite differently arranged from the stores of edible twigs. The young are born naked and blind; the mother suckles them and keeps them warm for a month and then brings them twigs, the bark of which they begin to eat. In six weeks they follow her out to her usual haunts, but remain under her superintendence for two years, after which they pair and set up in life for themselves. The intelligence of beavers is much higher than that of other rodents, and the long period of youth, under the tutelage of the mother, is occupied in learning not only what is necessary to the individual, but the art of living with other beavers in a well-disciplined community, doing work for the common good.

The beaver towns are only an extreme result of the gregarious habits found in most members of the group. Even when the period of youth is very short, and the mother is soon occupied with the cares of a new family, the deserted young remain together for a time. Young hares, when the mother has left them, haunt the form in which they were born, and play together for a good many months until they are nearly full grown, when they have to scatter because of the special risks of their mode of life in the open fields and woods. More often rodents live together in some kind of community, and it is very rare to find only a single pair in any suitable place.

Rodents usually follow the mother, and afterwards each

other, in single file, running along in well-marked tracks leading from their bolt-holes to the feeding-grounds. The South American coypu, a large aquatic rodent, makes a burrow in the bank of a lake or stream with the aperture under the water-level, or, if there is not a suitable position for this kind of nursery, constructs a platform-nest in the thick reeds alongside a stream. Six to nine young are produced at a time, active and furry, and are very soon able to follow the mother to the water. There some of them climb on her back and are carried about as she swims, whilst the others swim alongside. The nipples of the milk glands, instead of being placed in the usual fashion on the under surface of the mother, are arranged in a row at each side, very high up and nearer the middle line of the back, so that the young are able to suckle either as they swim alongside or as they crouch on the back.

Very little is known as to the breeding habits of sloths, armadillos and anteaters. Sloths spend their whole lives in trees, sluggishly creeping along the lower sides of branches, to which they hang by their curved claws. The young are born fully developed, no special nest being made, and are carried about by the mother, clinging to her hair with their long claws and clasping her firmly round the neck with their arms. Anteaters use their powerful claws, not for burrowing, but for digging out the ants and termites on which they feed. They make a lair in thick brushwood, and so far as is known produce a single young one at a time. This is fully clothed, and is carried about by the mother on her back for many months. The armadillos and pangolins all burrow, digging out very large chambers at the end of a long tunnel. In these the young are produced, usually three or four at a litter. The scales are at first pale and soft, and the young remain in concealment for a considerable time.

In all the marsupials the young are born in a very imperfect condition and are at once attached to the teats of the mother. These are placed far back on the body inside the marsupial pouch when that is present. The number of young at a birth varies, but it is never very large, in most cases one or two. The little animals are blind and naked, and even unable to suck. Each is attached to a nipple, and its mouth

grows into a sort of tube, which is sometimes so firmly attached to the mother that it cannot be torn away without bleeding.

All the kangaroos, wallabies and their immediate allies have a marsupial pouch in the female. This is a deep pocket in the furry coat, with the mouth opening forwards and protected by a circular band of muscle so that the female can shut it up to an extremely small hole or open it out widely. For a period lasting from a week in the smaller ones to several weeks in the larger animals, the infant remains motionless inside the pouch firmly attached to the nipple. It is not even able to suck, but has to have the milk squirted into its mouth by the mother. It then acquires a hairy coat, leaves the nipple, and begins from time to time to push its head out of the opening of the pouch and takes its first view of the world (Fig. 31). Soon after its first appearance it begins to nibble, and as the mother stoops down to crop grass or hay, the head of the youngster is thrust out and it also begins to pick at food. Gradually it learns to push out its head more and more, and even its fore-paws, but as soon as the mother is startled and sits up to look towards the source of danger, the young one retreats into the pouch, leaving only its head with bright twinkling eyes visible. Still later on the young one occasionally comes out of the pouch altogether, and feeds on its own account, hopping near the mother. At the first sign of danger, however, the mother stoops down, opens the pouch widely, and the young one bolts into it head first, and then wriggles round until it has reached its favourite position with only the head protruding.

All the marsupials, except perhaps the fierce thylacine and the Tasmanian devil, are preyed on by other marsupials, or by large eagles and other birds-of-prey, and escape by flight. If the young are small enough they are carried in the pouch of the mother, or run off at her heels. In a few cases, however, especially in arboreal forms, the young are carried on the back of the mother. The phalangers leap rapidly from bough to bough, or run up almost vertical branches with the greatest ease, and the females are often to be seen with one or more young clinging to their fur. The koala, or tree-

FIG. 31. Tree-kangaroo with young in pouch.

bear, a gentle, inoffensive creature, carries its single cub on its back. The American woolly opossums have long tails, the lower surface of which is scaly and used for grasping branches. The females carry their young on their backs, and each little creature supports itself by twisting the end of its tail round the tail of the mother. Male marsupials appear to take no interest in their families and do not assist in any way in the work of protecting them.

Thus, in many different ways, first in the womb, afterwards at the breast, keeping them warm, protecting and educating them, the mothers of mammals are in very close relations with their young, and in a smaller but considerable number of cases the fathers take some part of the burden of bringing up the family. The first result is an economy of life, for a much larger proportion of the young that are born have a chance of escaping the perils of youth and inexperience than in any other group of the animal kingdom. Next, this intimate association has led to a high development of the emotional and intellectual powers. In watching the relations between young mammals and their mother, we cannot avoid using the words and the ideas which we would use of the human race, and cannot doubt but that affection and tenderness, devotion and anxiety are experienced in the same way, if not to the same degree, as amongst human beings, and our kinship with animals is brought home to us far more closely than by the best-reasoned anatomical arguments.

CHAPTER XII

THE FOOD OF YOUNG ANIMALS

WHATEVER be the diet of fully grown animals, the young require food that is easy to digest and that contains much nutriment in proportion to its bulk. Fully grown animals have strong digestions and usually powerful jaws or teeth, or some other natural tools with which they tear and grind and pulp great masses of tough material and extract from it whatever nutritious matter it may contain. Young animals cannot easily deal with such substances; they must have their food in as concentrated a form as possible, and composed of materials as like the substance of their own flesh and blood as possible. It is curious that there is a similar difference between the diet of green plants and that of their seedlings. The mature plants stretch their leaves into the air, extracting from the thin gases of the atmosphere the necessary chemical substances to build up starch or sugar, whilst their rootlets, twisting through the soil, pour out a corrosive juice which dissolves the hard granules of mineral matter, and so enables them to absorb other necessary materials. The young seedlings cannot subsist on such a meagre fare; they live on the highly concentrated food prepared for them and packed round them within the seed-wall, and digest it by digestive juices not very different from those of an animal. In mammals where the reduction of families and parental care has reached its highest point, the first food and the only food for some time after birth is milk prepared from the blood of the mother, and this is the most complete food known.

The milk is secreted by the mammary glands which begin to swell and become active even before the young are born, and in healthy animals continue to give enough milk to feed the young animals until they are large and strong enough to be weaned. It is a striking fact that there is very little in the anatomy or the habits of the lower vertebrates to give

a clue to the origin of the milk glands which all mammals possess, or of the habit of feeding the young by a secretion from the skin of the mother. The skin of most fishes secretes an abundant mucus from little glands sometimes opening directly on the surface, sometimes into a set of canals on the head and sides of the body. The secretion no doubt helps to keep the skin smooth and soft and more fit to glide through the water, and is also useful in washing off the spores of moulds and fungi and other harmful parasites which might otherwise settle on the body. It may also be protective by being offensive to other animals. Living fish which have been captured and put in a bucket of water usually discharge large quantities of mucus; two or three hagfish put in a bucket may give off so much that the sea-water almost sets in a jelly. Frogs, toads and newts also give off an abundant slime which, besides its other useful properties, certainly has an offensive taste and protects them from being swallowed by many animals. A dog will not try to eat a frog or toad twice. In reptiles the skin glands are not so profusely scattered over the body; they are larger and arranged in definite places, and the skin as a whole is dry. Why so many persons believe that serpents are slimy I do not know; their skin is always absolutely dry. In lizards there are usually rows of skin glands along the inner side of the thighs; in turtles and tortoises on the soft skin between the junction of the upper and lower "shells," and sometimes under the chin. Crocodiles have large skin glands on the lower jaw, and snakes near the anus, whilst in some there are smaller glands near the edges of the mouth. It is certain in some cases and probable in others that the secretions of these large glands have a strong odour, often musky or disagreeable and often discharged when the animal is annoyed, as in the well-known case of the common English grass snake. In birds the skin generally is not glandular. There is a very large gland, the preen gland on the back, with a nipple from which an oily secretion is discharged, which the bird smears on its beak and uses to preen the feathers. In some of the aquatic birds there is a pair of glands on the lower jaw.

These various glands are protective, or odoriferous; and

may advertise the presence of their owners at the breeding time, but in no case is their secretion employed to feed the young. In mammals there are various masses of skin glands secreting odoriferous substances in different parts of the body: on the feet of ruminants, on the legs of horses, on the fore-arms of lemurs, on the tails of dogs and wolves, on the backs of peccaries and hyraxes, on the faces of antelopes and deer, on the temple of elephants, near the anus of carnivores and in many other situations, and it is these which may be most easily compared with the special glands of reptiles. Mammals have also two kinds of skin glands not found in other animals: the sweat glands which pour out a watery secretion that is partly a waste product and partly helps to regulate the temperature by cooling the over-heated skin, and the sebaceous glands which discharge an oily fluid at the roots of the hairs which automatically keeps them soft and flexible. The milk glands of all mammals are simply masses of much-enlarged sebaceous glands, and milk is an oily fluid to be compared with the ordinary sebaceous fluid. By what stages this became turned into milk and used for the feeding of the young it is very difficult to understand.

However they may have come into existence, the mammary glands of all female mammals secrete milk in sufficient quantities for the young and of much the same nature in every case. The milk of different mammals differs slightly in colour, taste and odour, but these qualities are of little importance, and just as the flesh of all mammals consists of the same kinds of substances in slightly different proportions, so the only food used to build up the flesh of young mammals consists of the same kinds of chemical materials.

By far the greater part of the weight of the body of an animal is made up of the water its tissues contain, and so from seventy to ninety per cent. of milk is water. Next in importance come the very complicated nitrogenous substances known as proteins, of which the most familiar example is the white of an egg. In milk the proteins form from one and a half to ten per cent., and are present as casein, the chief component of the curd which is formed when acid is added, and albumin, which becomes solid when milk is boiled.

Protein builds up the vital framework of the tissues; muscle, nerve, every living part of the body is simply living protein. In a fully grown animal protein does little more than repair waste, and under perfectly healthy conditions only so much protein is required in the food as is necessary to repair the wear and tear of life. In the young and growing body a much larger proportion of protein is necessary, as the tissues themselves are growing and have to be built up. Next comes the fat, which rises to the surface in the form of cream, or can be separated as butter. In different milks it varies in quantity from about one per cent. to ten per cent. and is present in different chemical forms. Fats are used to a very small extent in the actual building of the framework of the body. They are burnt in the tissues to supply heat and energy. The fats are suspended as little globules in the liquid of the milk and give it a white appearance. All milk contains sugar in proportions ranging from three to seven per cent. Milk sugar is chemically different from cane sugar or grape sugar, and also differs in different animals. The sugar of mares' milk, foı instance, can be fermented, producing alcohol, and this property is employed to make weak fermented beverages such as the well-known kephir and kumiss of the Caucasus and the Russian steppes; the lactose or milk sugar of cows' milk does not ferment in this way. The sugars, like the fats, play little part in the actual composition of tissues, but serve as fuel. Lastly, all milk contains a small amount of dissolved mineral matter, the ash which is left when it is dried and burnt, and this is practically the same as the ash when flesh is similarly treated.

There is nothing more important in the feeding of all animals, young or old, than not to put fresh food into the stomach until it has passed the last meal into the intestines, and still better until it has had a rest after being emptied. Under natural circumstances, when both the mother and young are healthy, there is little need to attempt to regulate this. The quantity of milk secreted by the mother and the rate at which it is formed supply more or less the right amounts for the wants of the young, and there is a good deal of natural elasticity as to quantities. Few young animals,

left to themselves, will take too much milk at a time; if they happen to do so, they get rid of it by the simple method of throwing it up; the overloaded stomach, as it churns the milk, cannot press it into the intestines and so forces it back into the mouth. Even when animals are being fed artificially, there is not much danger in giving them too much at a time; very little observation will show the quantity they can conveniently retain, and they should be allowed to take this, if it be certain that the proper time has elapsed since the last meal. Nature also regulates the intervals between meals rather well. The restless feeling of hunger, which drives an animal to move about until it finds the nipple, starts from the stomach, and under healthy conditions only from a stomach which has been empty for some little time. In artificial feeding, the hours should be carefully fixed. In the case of horses and other non-ruminant herbivores where digestion is chiefly intestinal and the stomach is small, two hours is a proper interval between meals, with a rather longer rest once a day, preferably at night. In the case of man and monkeys, the interval should be from three to four hours, and in the case of ruminants and carnivores at least five to six hours. These intervals apply to quite young animals, living only on milk; when they are older, and especially when other substances are added to the diet, the intervals may be made still longer. The important point to remember is that it is far better to give too long an interval than too short a rest between meals. In artificial feeding of young mammals, it is extremely necessary that each meal should be given from perfectly fresh and clean vessels, as the young are most sensitive to the slightest trace of putrefaction. It is also useful, at least until the animals are fairly strong and active, to give the milk as hot as they can take it without being scalded. There are many forms of feeding bottles and artificial nipples used for young animals, but it is really preferable to feed them with a spoon, an egg-spoon for very tiny things, and a large kitchen spoon for larger animals. Spoon-feeding can be made much more sanitary, as an open implement can be disinfected thoroughly, and it is more easy to regulate the quantity and to prevent an eager little creature

from choking than if it be given a nipple. It is surprising how quickly almost any kind of little mammal learns to be handled at feeding time, and to assist by opening its mouth for each spoonful. Moreover this method establishes a relation of confidence between the young animal and its guardian which is often of the greatest use in case of sickness. A small sick mammal often refuses to eat and still more to take medicine, and if it is unaccustomed to be hand-fed, the struggle to make it swallow is difficult and dangerous. If it has become accustomed to have a towel put round it (a process that at first frightens most older animals very much indeed), to have its mouth opened and a spoon used, it will submit to this even when it is well grown and capable of making a serious fight. Not only can it be fed, but many little operation such as cutting claws, removing milk-teeth or applying disinfectants can be carried out without binding or gagging, which, however skilfully performed, always upset the patient.

All young mammals pass gradually from a milk diet to the ordinary food of their kind, and under natural conditions the process of weaning is not abrupt. Young carnivores begin to pick at scraps from the prey of the parents almost as soon as their eyes are open and they are able to move about freely. When they are being reared by hand, they should be given raw meat as soon as they will take it freely, and the mistake of keeping them from it too long is made more often than that of giving it to them too soon. The cubs and kittens of all the cats, from the lion down to the smallest wild cat, can digest raw meat very soon, and if they have been kept on milk slops, scraps of cooked meat with gravy and vegetables and so forth, and are not doing well, a complete change to raw meat is almost miraculous in its rapid effect. The meat should be quite fresh, and it is better to change it, small rabbits, sparrows and so forth alternating with beef, mutton or horse-flesh. When the larger kinds of meat are given, bones with strips of flesh attached are the most suitable form, as although bolting food does them no harm, it is good that they should exercise their teeth and jaws. I have no doubt but that all the cats, wolves, foxes and even the domestic dogs

should be put on a raw meat diet as soon as possible, and that they do best if they are kept on it. When they are quite small, a meal twice or even three times a day, with at least six hours' interval, is advisable, but later on it should be reduced to two meals and finally to one meal a day. It is the natural instinct of these animals to growl and snarl over their food, and it is extremely bad for their health and temper to tease and disturb them while they are eating. However savage they may have seemed to be, if they are left in peace they will come to their friends immediately afterwards and sit down and wash their faces and paws peacefully.

Apes and monkeys suckle for a long time and the change to ordinary food is gradual. Young monkeys have been observed very little in their natural surroundings, but as the parents do not seem to bring food to them, they probably have to begin by nibbling rough shoots and leaves, and probably most of them take grubs and insects and even young birds and eggs. In captivity they are dainty creatures, and it is even more important than with children not to pamper them. If they are given nothing but carefully cooked cereals, white bread and cultivated fruits when they first begin to eat, they will refuse rougher and more wholesome food. The digestive organs of monkeys are more capacious than those of man, in proportion to their size, and the greedy animals will eat until they can eat no more. Their food should contain plenty of "packing," that is to say, it should not be too nutritious in proportion to its bulk. Boiled potatoes, wholemeal bread, rather hard apples, vegetables with plenty of fibre in them, should form the bulk of their food, but they will not take such things if they are accustomed to grapes and ripe bananas, sweet biscuits and carefully prepared milk puddings. Young monkeys, even more than young carnivores, should be accustomed to have their mouths opened, and to be fed with a spoon. They are delicate, even when they are not shut up in a warmed house and allowed free access to the open air in all weathers, and one of the first symptoms of illness is the refusal of food. They are almost as difficult to feed forcibly without doing them damage as are hysterical

women, unless they are thoroughly accustomed to being handled.

Young herbivorous animals of all kinds begin to pick at any kind of vegetable food in a few days, although they may continue to suck for months, or even years, until the mother ceases to give milk. In captivity they should be encouraged to eat, but dry foods of all kinds, especially dried leaves and clover, are most wholesome for them. If they are being hand-reared, however, they should not have free access to such food at all times until they have begun to ruminate, but small quantities should be given them instead of one of their milk meals, and cleared away after a quarter of an hour, or given immediately before a meal and similarly cleared away. For that reason it is better to keep them on a litter such as peat-moss, which they will not nibble, than on soft hay or straw.

The appetites of all young animals are veiy capricious if they are not thriving, and unless they have been accustomed to hand-feeding, they must be tempted in all sorts of ways, with all sorts of flavours, before the last expedient of forcibly cramming them is adopted. Thc great matter is to get them to eat anything first, and then gradually to change them to a proper diet. All sorts of unexpected flavours are occasionally relished by animals. A young orang, which had refused all food, was tempted to eat and brought back to normal food and health on several occasions by flavouring its milk with stewed rhubarb. The young elephant-seal in the London Zoological Gardens, which ought to be purely a fish-eater, acquired so voracious an appetite for buns that the public had to be warned against feeding it. Once in the absence of the proper official I had to try to give a young bear a dose of castor oil. After half an hour's struggle, in which the keeper and I both got scratched and bitten and had our coats torn, we succeeded in forcing perhaps half a teaspoonful down its throat. We gave it up, and as a last chance I poured some out in a dish and left it in front of the bear, which at once rushed at it, and greedily drank it all up. Patience and experiment are the most successful methods with all animals.

I have already spoken of the care given by birds to the

feeding of the young. In the brush turkeys, probably alone among birds, it does not occur, but the full-fledged chicks look after themselves as soon as they are hatched. In the birds that are hatched in a downy and active condition, the parents may actually bring food, or may only call the attention of the young to food they scratch up.

In ducks and geese the young are taken to food rather than actually fed. In the vast army of birds which are hatched in a helpless condition, the young are fed from the beginning. Since the young of birds are either fed or watched by the parents, they have the racial habit of confidence, and the new-hatched young or the fledglings of even the shyest or fiercest of birds are all perfectly ready to be fed by human beings, and only acquire their dread of man when they are grown up. All that is necessary is to know their habits, or to find out by experiment whether the food must be thrown down for them to pick up or actually put into their mouths, and they themselves assist by showing what they want. Most birds that are hatched in a nearly naked condition must have the food put in their mouths, and this applies also to most shore-birds and aquatic birds, whilst most of the ground-birds and game-birds pick it up for themselves.

I do not know of any instances in which the young of reptiles are actually fed by their parents. They are hatched or born in an active condition, and very quickly begin to eat on their own account. By far the greatest number of them are carnivorous, and when they are small should be supplied with worms or grubs, very small fish or frogs, or strips of meat cut into worm-like shapes, or eggs broken open or even hard boiled and broken up. A few of the lizards and the land tortoises are vegetarian and will eat fruit, berries, lettuce and other green food, but even these will take also slugs and grubs, particularly when they are young.

Reptiles are rather capricious feeders, especially in captivity, and the difficulty is the greater because they all are able to fast for very long periods without coming to harm, and it is not easy to know at what point it is necessary to take active steps to make them feed. The surest device, however, is to warm the little reptiles well before trying to feed them.

Little alligators and crocodiles, small water-tortoises and many little snakes will usually feed readily if put first in a bowl of water heated to a temperature of about 100° Fahr., and snakes and lizards and land tortoises should be put in front of a hot fire (with, of course, the chance of wriggling away if they find it too hot) or taken into the hottest compartment of a greenhouse. In the first winter of their life they should be wakened up by this method and offered food at least once a week. When they are older, if they have been well fed through the autumn and are plump and heavy, they need not be disturbed.

If natural methods fail, cramming may be readily carried out with most reptiles, and is sometimes successful. It is comparatively easy, because the gullet is wide and runs straight back to the stomach from the line of the floor of the mouth, and there is little danger, if use be made of a blunt instrument incapable of doing damage to the back of the mouth and throat. Young crocodiles, alligators, turtles or lizards should be held firmly with the left hand and gently tickled along the soft skin near the hinge of the upper and lower jaws until they gape, when a bolus of meat can easily be placed far back in the mouth and pushed down the throat. Snakes have to be handled more gently, partly because their ribs are very easily broken when they struggle, and partly because if they wriggle, the rather long gullet may not be straight and its wall be damaged. I once saw a twenty-foot python being stuffed in a foreign Zoological Collection. Its own keeper seized hold of it just behind the head and pulled it out of its cage coil by coil, whilst a set of assistants took their stations behind him, each grasping firmly a successive portion of the snake as it was handed out. Finally, nine or ten keepers in a row were holding the python and had much ado to keep it straight. The food, which consisted of four skinned rabbits arranged like a sausage on a long pole, had been prepared beforehand. The keeper at the head then opened the jaws of the snake, and a waiting expert slowly pushed the pole with the rabbits down the throat of the snake until he had got it quite home. The pole was then slowly withdrawn, and the rabbits were left behind, and the mouth

of the snake was cleaned and disinfected. The last stage of the operation was to buckle a leather strap rather tightly round the neck of the python, as otherwise it might have disgorged the food that it had been compelled to take.

This raises the very interesting and difficult question as to the giving of a living prey to reptiles in captivity. The Buddhist standpoint may be taken, and those who are of the opinion that it is wrong under any circumstances to procure or connive at the extinction of life may go the extreme length of refusing to give mealworms or cockroaches to lizards, or worms and little fishes and frogs to alligators and snakes. For most persons, however, the doubtful point comes when it is a question, not of giving small and unintelligent creatures to animals that will bolt them whole and certainly kill them as instantaneously as can be done, but of giving birds and mammals to large snakes. The problem, therefore, fortunately does not arise with very young snakes, but as it is interesting and as I have given special attention to it, I may digress to discuss it.

The large poisonous snakes when they are restless and show that they are hungry generally dart at their prey as soon as it is put in the cage, strike at it, inject the poison from their poison fangs with the rapidity of lightning and then withdraw and wait for some time before they proceed to swallow it. The victim dies very quickly, as quickly as it can be killed by almost any method, and, so far as it is possible to judge from its behaviour, painlessly. So also when a constricting snake, like a python or anaconda, is really hungry—and the expert keeper can almost unfailingly recognise that condition—it strikes almost at once at the prey, seizing it with its mouth, and with an indescribably rapid movement throws one or two heavy loops of its body over it and crushes it. If the animal struggles, further coils are thrown over, and in a very short time the creature is smothered. Even if it showed signs of being hungry, the snake generally waits some time before beginning the long process of swallowing the prey, which is always dead and sometimes quite cold first. When the snake is hungry and has proper accommodation to strike and smother its victim, I think the actual death in this case, too, is

as often painless as when an animal is killed for human food.

It is necessary to insist, however, on the fact that in both cases the prey is extremely seldom eaten for some time after it is dead. If the mouse or rat, guinea-pig, duck or goat has been first killed by the keeper, and thrown into the cage of a really hungry snake, the snake, whether poisonous or a constrictor, will behave exactly as if the victim were alive, will strike at it and withdraw in the one case, or strike at it and throw a coil over it in the other case, and in time proceed to eat it as if had not noticed the difference. If the snake is not very active and has to be excited or tempted, this can very often be done by dangling the dead prey at the end of a pole or some other simple mechanical device. It is my personal opinion that in nearly every case a snake, if it be kept properly warm and not fed except when it is either hungry or ought to be hungry, can be induced to take dead food. And I have no doubt but that it digests the food which has been killed by a keeper just as well as when it has killed it itself. My own experience and observations have led me to believe, against the opinion of many experts, that there is very little in the view that the digestive secretions do not work properly unless the snake has had the excitement of killing its own food. A hungry, healthy snake has an excellent digestion, and can deal very well with anything it has swallowed. I believe also that there is less than nothing in the curious, half-superstitious notion that living food is better for living snakes than dead food. The small snakes certainly usually take their food alive, but they will take killed food, if it is fresh, equally well, and the large snakes always wait until their prey is dead before they eat it.

There remain, however, a small number of cases in which individual snakes refuse all persuasion and would probably die unless they are allowed to kill their victim. Such cases certainly do occur, and those who have to deal with them must decide them according to their own sense of what is right, whether to let the snake die or to let it kill its prey. Some years ago, to make up my own mind, I made a number of observations with my colleague, Mr. R. I. Pocock, to ascer-

tain the behaviour of different animals in the presence of snakes. Clearly, if animals are really frightened in the presence of snakes, there is much more than the mere fact that they are killed and eaten to be considered before we use them as food, especially if the snake to be fed is not very active and does not seize the prey at once. The usual animals used for food, besides fish, frogs and worms, are pigeons, ducks, rats, rabbits, guinea-pigs and goats. I have watched, very carefully, what happens when these are put into the cage of a snake and are not seized at once. At first, just like any animals put in a strange place, they look about them, and if they are not quite tame they may bolt to the darkest corner. Presently, however, they become at home. The ducks waddle about, the pigeons preen their feathers, rats, rabbits and guinea-pigs scamper all over the cage or sit up and wash themselves, and goats behave precisely as they do in any enclosure. None of them pay the slightest attention to the snake if it is merely lying quiet, and I have seen all of them walk over the snake and lie down on it or beside it with complete unconcern. When the snake moves, they get out of its way or push against it, just as they would do with a stick, or another harmless animal of the same kind. They have no special dread of snakes, nor the slightest instinctive fear or foreknowledge of their approaching doom. We tried a further set of experiments by taking a large tame snake, which was very active, to the houses in which various animals were kept, and at the Royal Institution I repeated some of these experiments in public, by introducing various animals in turn to a snake, if they could be taken out of their cages, or by holding the snake against the cage in which they were contained and letting it move over the cage or even try to get its head through the bars. The snake that was used was not a poisonous one, but I should not expect animals to notice a difference to which very few human beings would pay any attention. A great many different ground-birds and water-birds were tested; fowls, pheasants, ducks, geese, rails, coots and so forth either paid no attention to the snake or tried to peck at it, in the fashion that they would peck at any moving object. Parrots and cockatoos were equally indifferent. A yellow-crested

cockatoo which I had at the Royal Institution amused us by being really frightened of a guinea-pig, raising its crest and making a great fuss, but showing itself completely unconcerned when the snake writhed and twisted towards it. Some of the more intelligent of the passerine birds, and in especial an Indian hill mynah, showed their knowledge and dread of the snake in the most definite way. The mynah's cage had been covered up, so that the snake appeared to it quite suddenly, and it began to shriek in an excited way and darted up to the remotest part of the cage with so great a fear that we had to remove the snake at once. Immediately afterwards the bird came to the bars and pecked at my fingers in a friendly way, and showed the same attention to the guinea-pig. It was not a shy bird or timorous, but it knew snakes and feared them.

Moreover, nearly every kind of mammal that we tried was indifferent to snakes. Guinea-pigs and rats would run over them; a hyrax, which is both intelligent and which from living in trees and on rocks must often encounter snakes, was hardly even interested. When the snake touched it with its tongue, the hyrax moved back suddenly, just as when someone it did not know touched it, but immediately afterwards stretched out and sniffed at the reptile, and then, satisfied that it was not good to eat, took no further notice. Small carnivores, dogs, foxes and wolves, sheep, antelopes and deer, zebras and donkeys were either quite indifferent or came up to the bars and sniffed, and then, deciding that the snake was not a bun or piece of sugar, moved away with an air of wearied disgust at having been deceived. As monkeys are well known to recognise snakes, we tried nearly every different kind in the Zoological Gardens. Lemurs of all kinds have no dread of snakes and show no trace of any knowledge of them. Without exception, they all came to the bars of their cages expecting to be fed, and tried to snap at the snake as they would at any kind of food. The small American monkeys, which are less intelligent than the monkeys of the Old World, were uncertain in their behaviour. Several marmosets, although these are shy and timid creatures, and must often be the victims of snakes in their native

land, acted rather like lemurs, being indifferent or very curious. Capuchins and howlers, spider monkeys and woolly monkeys, however, nearly all behaved like their Old World allies. And there is doubt as to the recognition of snakes by the ordinary macaques and cercopitheques, the baboons and mandrills. As soon as a snake is brought into the monkey-house there is a great outcry. The first monkey that sees it gives a peculiar scream and dashes off to the highest and farthest part of the cage, and the others at once come to see what is the matter, and in turn dash away. From the largest baboon down to the smallest macaque all were equally frightened and excited. At the Royal Institution I showed a snake successively to a lemur, a very young cebus monkey and a young Arabian baboon. The lemur had been born at the London Zoological Gardens and probably had never seen a snake until that day; the two little monkeys were still very young, and had come to the Gardens when they were such babies that almost certainly they could have had no individual experience of snakes. The difference in the behaviour of the lemur and the monkeys was startling. The lemur, like all the others I had tried, was almost aggressive in its want of fear; the monkeys were panic-stricken, and the snake had to be removed at once.

The anthropoid apes in the Ape House at the London Zoological Gardens were also tried with various kinds of snakes. The gibbons were least timid; a very small agile gibbon showed no fear and very little curiosity, while a full-grown example of the same species and a hoolock gibbon showed no panic, but retreated very decidedly. It is possible that gibbons, as they are the most agile and completely arboreal of all the monkeys, run little risk from snakes and have partly lost their fear. The chimpanzees, except one baby which took no notice, recognised the snakes at once and fled backwards, uttering a peculiar, soft warning cry. They then became more excited and began to scream, getting high up on the branches or wirework of their cages, but keeping their eyes fixed on the enemy all the time. They soon took a little courage and drew nearer in a body, chattering loudly, but fled off screaming again. The panic in the presence of snakes

was most sudden and complete in the case of orangs. When I tried the experiment, there were two unusually fine examples in the collection, one a large and probably adult male, the other a well-grown young female that had been two years in the Gardens and was very tame and gentle. Both of these animals were usually most deliberate in their movements, coming slowly across the cage even for their favourite food, and climbing as if it were too much trouble to move. But as soon as they caught sight of a snake and long before it was near them, they fled silently, but with the most unusual celerity, climbing as far out of reach as possible.

Most certainly it would be cruel to supply snakes with living monkeys as food. Except for a few of the more intelligent passerine birds, monkeys are the only animals with an instinctive deep-seated terror of snakes. Such an instinctive terror does not exist in most animals, and certainly there is no trace of it in any of the birds and mammals, the frogs and fishes that are usually given alive to snakes. The instinctive dread of snakes that so many, perhaps most, human beings display is simply one of the many legacies that we have inherited from our monkey-like ancestors, and we are quite wrong if we suppose that all animals or most animals possess it.

Whilst I was making these observations, I was anxiously on the watch for any signs of the fascination which so many persons say is exercised by snakes on other animals, especially on birds. I have now seen a very large number of birds and small animals in the presence of snakes, both under natural conditions and in captivity, but I have never seen any trace of what is described so often and so graphically, of a bird or little mammal being fixed by the beady, glittering eye of its enemy, and then inevitably, drawn by some invisible force, slipping down the branch or along the ground until it falls into the jaws of the reptile. What I have seen again and again is a display of the power of attention. A sudden movement may frighten away a bird or mammal at once, but if any object—the tip of an umbrella, the human hand, or the head of a snake—be pushed forwards very slowly and quietly, the bird or mammal turns round, fixes its attention on

the moving spot, and if no sudden noise or jerk be made, the umbrella or the hand may reach the creature, or the snake come at striking distance of its victim. But I have never seen any sign of the victim being, so to say, hypnotised or itself approaching the snake, and at any moment too great eagerness on the part of the snake, or any sudden noise, makes the prey move off.

CHAPTER XIII

THE TAMING OF YOUNG ANIMALS

PRIMITIVE man was a hunter almost before he had the intelligence to use weapons, and from the earliest times he must have learned something about the habits of the wild animals he pursued for food or for pleasure, or from which he had to escape. It was probably as a hunter that he first came to adopt young animals which he found in the woods or the plains, and made the surprising discovery that these were willing to remain under his protection and were pleasing and useful. He passed gradually from being a hunter to becoming a keeper of flocks and herds. From these early days to the present time, the human race has taken an interest in the lower animals, and yet extremely few have been really domesticated. The living world would seem to offer an almost unlimited range of creatures which might be turned to our profit, and as domesticated animals minister to our comfort or convenience. And yet it seems as if there were some obstacle rooted in the nature of animals or in the powers of man, for the date of the adoption by man of the few domesticated species lies in remote, prehistoric antiquity. The surface of the earth has been explored, the physiology of breeding and feeding has been studied, our knowledge of the animal kingdom has been vastly increased, and yet there is hardly a beast bred in the farmyard to-day with which the men who made stone weapons were not acquainted and which they had not tamed. Most of the domestic animals of Europe, America and Asia came originally from Central Asia, and have spread thence in charge of their masters, the primitive hunters who captured them.

No monkeys have been domesticated. Of the carnivores only the cat and the dog are truly domesticated. Of the ungulates there are horses and asses, pigs, cattle, sheep, goats and reindeer. Among rodents there are rabbits and guinea-

pigs, and possibly some of the fancy breeds of rats and mice should be included. Among birds there are pigeons, fowls, peacocks and guinea-fowl, and aquatic birds such as swans, geese and ducks, whilst the only really domesticated passerine bird is the canary. Goldfish are domesticated, and the invertebrate bees and silk-moths must not be forgotten. It is not very easy to draw a line between domesticated animals and animals that are often bred in partial or complete captivity. Such antelopes as elands, fallow-deer, roe-deer and the ostriches of ostrich farms are on the border-line of being domesticated.

It is also difficult to be quite certain as to what is meant by a tame animal. The real quality of tameness is that the tame animal is not merely tolerant of the presence of man, not merely has learned to associate him with food, but takes some kind of pleasure in human company and shows some kind of affection.

On the other hand we must not take our idea of tameness merely from the domesticated animals. These have been bred for many generations, and those that were most wild, and that showed any resistance to man, were killed or allowed to escape. Dogs are always taken as the supreme example of tameness, and sentimentalists have almost exhausted the resources of language in praising them. Like most people, I am very fond of dogs, but it is an affection without respect. Dogs breed freely in captivity, and in the enormous period of time that has elapsed since the first hunters adopted wild puppies, there has been a constant selection by man, and every dog that showed any independence of spirit has been killed off. Man has tried to produce a purely subservient creature, and has succeeded in his task. No doubt a dog is faithful and affectionate, but he would be shot or drowned, or ordered to be destroyed by the local magistrate if he were otherwise. A small vestige of the original spirit has been left in him, merely from the ambition of his owners to possess an animal that will not bite them, but will bite anyone else. And even this watch-dog trait is mechanical, for the guardian of the house will worry the harmless, necessary postman, and welcome the bold burglar with fawning delight. The dog is a

slave, and the crowning evidence of his docility, that he will fawn on the person who has beaten him, is the result of his character having been bred out of him. The dog is an engaging companion, an animated toy more diverting than the cleverest piece of clockwork, but it is only our colossal vanity that makes us take credit for the affection and faithfulness of our own particular animal. The poor beast cannot help it; all else has been bred out of him generations ago.

When wild animals become tame, they are really extending or transferring to human beings the confidence and affection they naturally give their mothers, and this view will be found to explain more facts about tameness than any other. Every creature that would naturally enjoy maternal (or, it would be better to say, parental care, as the father sometimes shares in or takes upon himself the duty of guarding the young) is ready to transfer its devotion to other animals or to human beings, if the way be made easy for it, and if it be treated without too great violation of its natural instincts. The capacity to be tamed is greatest in those animals that remain longest with their parents and that are most intimately associated with them. The capacity to learn new habits is greatest in those animals which naturally learn most from their parents, and in which the period of youth is not merely a period of growing, a period of the awakening of instincts, but a time in which a real education takes place. These capacities of being tamed and of learning new habits are greater in the higher mammals than in the lower mammals, in mammals than in birds, and in birds than in reptiles. They are very much greater in very young animals, where dependence on the parents is greatest, than in older animals, and they gradually fade away as the animal grows up, and are least of all in fully grown and independent creatures of high intelligence. But these, because they are intelligent, *may* learn, even when they have been captured as adults, that they have nothing to fear, that the bars of their cage or the boundaries of their enclosure not only restrain them from attacking persons outside, but restrain the persons outside from disturbing them. Very fierce and fully adult mammals *may* settle down quietly to captivity, and learn that the visit of a keeper

is a pleasant source of food, that cleaning out the litter and washing the cage are not schemes to annoy them, and almost in proportion to their intelligence will tolerate captivity. The shyest of wild birds will breed peacefully a few inches from the wirework of their enclosure, or will display complete fearlessness of the visitors who are on the other side of the fence, often simply because birds that are naturally intelligent have learned to be shy in the wild condition, and equally learn not to be shy where they are protected.

All young primates are gentle and easy to tame. The gorilla is reported to be one of the most savage, as he is one of the most powerful and well armed, of creatures. I do not think that any adult gorilla has ever been captured alive. But young gorillas are very well known, and many individuals have been brought to Europe at ages varying from a few months to five or six years. When some one really fond of animals and intelligent in managing them obtains specimens, and keeps them until they have become thoroughly accustomed to human society and to the food that they would afterwards receive, they can be successfully reared, and are found to surpass the other great apes in the humanity of their intelligence as they do in size and structure. Orangs are better known because, although they, too, are delicate, they have been reared much more successfully in captivity. The adults in their native woods, the steaming tropical forests of the Malay Archipelago, are almost as suspicious of man as the gorilla, and their enormous jaws and powerful hands and feet make them dangerous foes. Young orangs are extraordinarily docile and very affectionate, and have been taught many strange tricks—to wear clothes, to sit at table for their food and to eat and drink with spoons and cups. They are slow and sedate in their movements, and as they are watchful and attentive, they quickly learn what their keepers wish them to do. But although they are more hardy than gorillas, they have to be kept under such careful conditions and have lives so uncertain that their training has never reached very great lengths.

Chimpanzees are much the most hardy of the anthropoid apes, and their character and capacities are best known.

They are all extremely excitable, and occasionally fall into almost hysterical fits of temper, when they scream loudly, and will bite even their best friends, and as they have considerable strength and fight with their teeth and hands and feet simultaneously, they are not always quite safe. Apart from occasional fits of temper, and if they are well treated and not unduly forced to do tricks when they are unwilling, chimpanzees show extreme affection and docility. They recognise their friends after long absences and show the greatest excitement and joy when they return. It is unnecessary to describe all that they have been taught to do; they ride cycles, perform on the trapeze, put on and off clothes, open or close doors, help in sweeping their cages, use forks and spoons, cups and drinking-glasses.

Gibbons are less intelligent, but young gibbons soon become docile and are always gentle and friendly. All young baboons and African, Asiatic and American monkeys that I have seen are quite ready to become gentle and tame and to take to human beings, and the various ingenious tricks that they have been taught are well known. Lemurs are less intelligent, but are equally ready to become tame.

At the Zoological Gardens, the chimpanzees as they grow up seem to me to become less tame, but that may be partly because the keepers have to cease being so familiar with them when they grow stronger, and when considerable force would have to be used if they fell into a fit of temper. For the same reason baboons and monkeys and lemurs are not handled so freely as they grow up, but it certainly is my opinion that apart from this, their tameness wears off.

All young monkeys are climbing animals, accustomed first to cling to their parents and then to run along branches with the help of their hands and feet. They dislike being caught hold of, and, until they are really familiar with you, they will be frightened or try to bite if you make any attempt to seize them. If, however, they are allowed, they will climb on to you, running up your arm and sitting on your shoulder, or clinging round your neck. This applies not only to quite young monkeys but to many that are full grown; they will struggle and bite if you try to grasp them, but they will

readily allow themselves to be carried. Whe
become familiar, and are given an arm by wh
on, they will allow themselves to be groomed, to
fur combed and brushed, and their faces, feet and ha d
the naked parts of their body washed. One of the difficulties in keeping monkeys is that it is almost impossible to train them to cleanly habits. Like most arboreal animals, they have no special place to keep clean and no natural disposition to avoid fouling their blanket or the floor on which they are. I have seen a chimpanzee that was trained to use a lavatory, but it plainly acted as if it were one of the tricks that it had been taught to perform and did not associate it with the object in view. It would go through the operations when it had no need, and immediately afterwards would foul the floor or its clothes. With regard to cleanliness, the most careful training can only develop the natural instincts of animals.

I do not know any exception to the rule that carnivores, which are naturally accustomed to maternal care, are easily tamed and when young make gentle and affectionate pets. Baby tigers, lions, leopards, cheetahs, caracals, lynxes, all the bears, hyenas, dogs, wolves, foxes and all the smaller creatures in the group attach themselves extremely readily to man. As they are usually carried in the mouth by the mother, unlike monkeys, they expect to be picked up, and prefer firm, almost rough, handling. As the mother licks them over and cleans them, they like being brushed and scrubbed with a rough damp towel. Most of all they like being caressed and petted and allowed to sleep snuggling in a warm lap. Not food, but warmth and physical contact are the surest ways to their affections. But all of them, and especially the cats, retain a good deal of independence. They like to be left alone sometimes, to retire into a particular dark corner which they have selected, and will be rather unpleasant if they are dragged out when they do not wish society. If they are left alone, they will soon come back. To be fond of companionship is no peculiar gift of the dog. All the carnivores dislike being left alone long, and will scream loudly if they are shut up, or quickly learn the habits of their owners and follow them from place to place.

It is no part of the domesticated nature of the cat and dog that these are easy to train to cleanliness in a house. In their very young days, the cubs and kittens of the catlike carnivores and of the wolves and dogs and foxes are kept clean by the mothers, but as soon as they are able to move about they are scrupulous in avoiding the soiling of their bedding, or the floor of the room in which they are kept, and if a box with sand, or better still with fresh turf, is kept in a dark corner, they will find it themselves and hardly have to be taught. It is almost a certain sign of illness in any of these creatures if they become dirty in their habits. The various small carnivores that live in trees, like palm-civets and so forth, are a little more troublesome, but they are very easily taught. When the teeth begin to develop, young carnivores naturally try them on every possible object, living or inanimate, within their reach, and it is necessary to teach them not to bite their owners, as even in play they may do a good deal of damage. They even bite their mother, until she teaches them, with rather sharp pats from her paw, what it is permitted to bite and what is taboo. With the different kinds of cats, from tigers to the domestic cat, a little rap on the upper surface of the nose is the safest and most effectual form of punishment. When this has been done once or twice, it is quite enough to lay the finger on the nose, and the little animal will understand and remember. It is more difficult to teach them not to use their claws when they get excited in play, or merely when they are jumping or climbing on one. The claws of small leopards, caracals and so forth are as sharp as needles, and when they are quite young they dig them in automatically. Later on when they are older, they will romp in the wildest way, strike quite hard blows with the paws, and submit to very rough handling without unsheathing their claws. It is only when they are being teased, especially over food, or when they are in a temper and are lying on their backs refusing to be picked up, that there is any danger of their striking with unsheathed weapons. It is safer, however, to keep the points cut; this is quite necessary when they are babies, and if they have been accustomed to the process then, they will allow it to be done when

they are nearly grown up. Each claw should be pressed out of its sheath in turn, and the end nipped off with very sharp scissors or nail-clippers. The instrument must be both strong and sharp, as the nails split rather easily. The instinctive movements of young carnivores are fitted to retain hold of a living, struggling prey, and the most certain way to be bitten or clawed is to stretch out the hand timidly and try to draw it back. The creatures must be seized firmly and at the first movement, and if they put out their claws or close their teeth, do not try to pull the hand away. They will do no further damage and after holding on for a few minutes they will let go.

Carnivores have excellent memories and recognise their friends even after years of absence. Animals that come to the Zoological Gardens as young and tame cubs generally remain easy to deal with, and again and again, long after they had ceased to be petted and handled, I have seen them welcome their original owner. The same difficulty exists with carnivores which have grown up as with the large apes. The danger of continuing to treat them with unconcern is too great, as the result of a fit of temper or a sudden fright might very readily be fatal to those who had rashly ventured within their reach. It is certain, moreover, that they distinguish acutely between persons, and an animal that is quite tame with one keeper or person may be extremely dangerous with others. They are extremely nervous, and the slightest hesitation or want of resolution in approaching them may alarm them and cause trouble. It is not quite certain, therefore, what would be the result of the experiment of continuing to treat fully grown lions, tigers, bears and so forth with the same familiarity as when they were cubs. This is simply following the natural order of events. In the wild condition, apart from the influence of man, they are gentle and affectionate when they are young, but when they are fully grown have to display habits more suited for the unfriendly world in which they live. Human influence retards but does not prevent this inevitable and necessary change.

Although I am inclined to admit, reluctantly, the truth of the general belief that the friendliness of carnivores is an

episode of their youth, there are two other well-known popular beliefs about them for which I have found no evidence. The first is the supposed change in their habits at night. I have again and again been told, with regard to young tame animals in my own possession, that they might be safe by day, but that at night their prowling, savage instincts would awaken, and that they would seize me by the throat. I have often gone at night to play with nearly full-grown young leopards, both the common leopards and snow leopards, which knew me by day, and I have found them as friendly and as gentle then as at any other time. A young tame caracal slept nightly on a towel alongside my pillow until it was nearly a year old, and although it was sometimes restless and would wake me up to be let out by patting my face, there was no change in its behaviour at night or in the day.

Young seals, sea-lions and walruses are extremely easy to tame. It is quite certain that they remain with their mothers for a long time and are very fond of companionship. As those that arrive at the Zoological Gardens are generally young animals which have recently been taken from their mothers, at first they mope very much, and it is extremely difficult to induce them to eat or to be consoled. It is curious that the seals which have most experience of man, such as the grey seal and the common seal, seem to have almost an inherited fear of him, and although they can be tamed, do not settle down so quickly, and not infrequently pine and die. Seals from remoter waters, such as the elephant seal from the South Indian Ocean, the sea-lions from Africa, Patagonia and California, and the walruses from the icy seas of the North become reconciled to captivity almost at once. A similar difference between the wild animals of civilised and populous countries and those of remoter regions exists in many other cases. Fear of man is no special instinct of animals; those that have little acquaintance with him are curious about him rather than frightened of him, but those that have been forced to make his acquaintance at close quarters have had to learn to avoid him and fear him almost as a condition of their existence. When seals of any kind do survive the early days of their captivity, they become very

tame and docile, following their keepers from place to place and being anxious to rub against them and nuzzle them. It must be even more difficult for these animals than it is for the predaceous land carnivores to learn the serious business of hunting, and it is probably only after a long apprenticeship with their mothers that they become able to find and to catch fish for themselves. It is not surprising therefore that they are friendly and attentive and have high powers of intelligence. Common seals, grey seals and sea-lions have frequently lived in zoological gardens long after they have become adult, and I have never heard of a case in which they lost their tameness or were in any way dangerous to their keepers. They are all gregarious, living in numbers in their favourite haunts, and certainly giving one another warning of approaching danger, and it is only in the breeding season that the males are savage, when they engage in fierce battles and try to steal each other's wives.

The young of hoofed animals are all accustomed to run with their mother from their first days, and most of them readily transfer their companionship to man. Few of them show any high degree of intelligence, but they distinguish between individuals, recognising them both by voice and by smell, but to a much smaller extent by sight. They like being stroked and fondled, but, except when they are very young, resent being seized hold of or lifted, and are extremely easily scared by any unusual sight or sound. Not only do they follow their mothers when they are young, but most of them are gregarious, and the herds or flocks are accustomed to follow a leader. This is true even in the domesticated animals, and the familiar English sight of a herdsman or shepherd driving his animals with barking dogs and much shouting, or struggling with a pig, is wholly unnatural. Ungulate animals, young or old, learn to follow a human being as surely as they would naturally follow their mother or the leader of their herd. Their affection, however, is seldom much more than a fear of being left alone, a desire for companionship, and the hope of getting some tit-bit to eat. Those that are not domesticated seldom retain much regard for or confidence in human beings after they have grown up, and nearly all of

them are dangerous in the breeding season.

Even if they were suitable otherwise as pets, young tame ungulates must be kept out of doors, for none of them, or almost none of them, has the natural habit of cleanliness, and so they cannot be trained to observe the proprieties. The best-known exceptions are the swine, which will not foul their own litter if they have an opportunity of choice, and will generally select a remote corner of their run to deposit their droppings. One other exception was a great surprise to me. My tame tree-hyrax, almost as soon as it came into my possession, chose the old green baize cover of a typewriter, which happened to have been thrown down in a corner of my study, and afterwards remained faithful to this selection. When it was kept ready for it, it would seek it out of its own accord, and when the little animal was taken there at night, before going to bed, it at once made use of it. The coney, another species of hyrax, is, according to the Bible, "exceeding wise," but this particular form of wisdom was very unexpected, and very unlike the habits of other hoofed animals.

Everyone knows that young elephants are gentle, playful and friendly, and that they attach themselves strongly to their keepers. Their memory is very good, and neither young nor old elephants forget an injury or a kindness easily. Their powers of climbing, balancing and jumping, often seen in trained performing elephants, are quite natural developments of their capacities, for elephants are extremely active in their native haunts and climb steep rocks very well. They usually retain their tameness when they grow up, except at special seasons when males are dangerous. Their docility is the result of their natural disposition, their long association with their mother and their social habits. It is not due to domestication. Even the Indian elephant is a tamed rather than a domesticated animal. The stock is kept up much more by the capture of wild animals than by breeding in captivity, and young and old African elephants, which have not been domesticated in the sense that has happened in Asia, are just as docile and easy to manage.

I have already mentioned the hyrax. It is in every sense a wild animal, and although it has bred in captivity, I do

not know of this having gone on for more than one generation. Nor do I know any one, except myself, who has had the good fortune to own a tame tree-hyrax, but tame examples of the animal from South Africa, East Africa and Syria have been known, and their owners agree as to their engaging character. They are amusing, very affectionate and intelligent. They are expert and tireless climbers, and no doubt as a result of their habit of riding on the back of the mother, although they rather dislike being picked up, they like sitting on the ankle or hand or shoulder. My pet rushes to meet me as soon as I open the door of the room in which it has been kept, after an absence. It roams all over my study, climbing up the bookshelves wherever there is a vestige of foothold; I have seen it climb on the back of a chair placed against the smooth, polished front of a chest of drawers, stand on tiptoe and give a little jump so that the tip of one of its front paws just reached the top, and then pull itself up with the greatest ease. When it is tired of playing, it climbs on my lap and goes to sleep quite undisturbed by my work on a typewriter, although it is startled by every strange noise It uses its flat, naked palm to give a sharp rap on the floor or on the surface on which it may be resting when it is angry or excited by the sight of a strange person or a strange animal; but this is also a call note, for when it has hidden behind some books or in a dark corner, it comes out at once and runs to me when I imitate the sound it makes. The fully grown hyrax can defend itself well by giving sharp bites with its long incisor teeth. My little animal, which is able to give quite a painful pinch with its teeth, has learned to stop when I say "No," and to lay hold of my finger quite gently; it also will open its mouth when I tell it to do so. Although the hyraxes are ungulates, they stand very far away from the other ungulates and are probably as nearly related to the ancestors of men and monkeys as to the elephant and rhinoceros. They certainly have very little experience of human beings, and their intelligenee and capacity for being tamed are genuine outcrops of their constitution and habits.

The domestic horse and donkey have been subjected to so many generations of breeding that their qualities may be

taken to be the result of man's preference rather than of natural disposition. Young zebras, zebra-donkey and zebra-pony hybrids, and young wild asses of every kind that I know are as tame and gentle and affectionate as the young of the domesticated races. Like these, they readily learn to know their keeper and to follow him about, and to be stroked and patted. When they become adult, however, they very often are rather savage and treacherous, and some of the wild asses are amongst the most dangerous of the animals that are kept in captivity. What seems to have happened in the case of the horse and the donkey is not that the nature of the young has been changed by domestication, but that spirit and independence have been bred out of the race by getting rid of the adults which showed "vice," the name that we apply to the qualities that do not suit us. Tapirs, in my opinion, are stupid and rather uninteresting animals. The young follow the mothers closely, and parents and young interchange little shrill piping noises. Orphan young tapirs will attach themselves to a keeper. They are harmless, inoffensive creatures, but as they grow up become rather shy of human beings.

The relations between a young hippopotamus and its mother are intimate and long continued. The full-grown animals, although they know their keepers well, are not to be trusted, and if given the chance, would charge and do serious injury. The young of all the swine and of the peccaries become tame almost at once and show great affection for their owners. Young peccaries, wart-hogs and river-hogs have often been brought to the London Zoological Gardens by persons who had obtained them when they were mere babies, and who all speak with delight of their intelligence and devotion. As they are powerful, extremely active, and able to give most dangerous wounds when they are full grown, familiarity with them is generally dropped as they grow up, but they continue to recognise their owners and to show pleasure at their presence for many years.

Although camels have been domesticated for so long that the truly wild animal is unknown to exist, they have never really become tame. They know their masters and obey them within limits, but most of them are ready to bite at any time

and do not discriminate between friend and stranger. Young camels, certainly, are moderately docile and show some cup-board affection for those who feed them. The South American llama and alpaca have been domesticated almost as long as camels, but are less obstinate and more gentle. The wild forms of them, the small vicugna and the larger huanaco, are much more intelligent. They are extraordinarily active, rearing on their hind-legs, and dancing in the most curious ways. They recognise those who feed them, and the single males of each species in the London Zoological Gardens learned to recognise an individual visitor both by her voice and by sight. They would come rushing to her as she approached, and follow her to the front or the back of the enclosure, grunting with pleasure and offering their special welcome by spitting at her. Both of these were dangerous to their keepers.

The fawns of all wild deer and the young of all wild cattle, sheep, goats and antelopes readily attach themselves to man, submitting to a good deal of handling, liking to be petted, recognising their owners and readily following them. Equally I think they are all uncertain when they are adult, the males at the breeding season, and most of them all the year round. There are differences in temperament which are not easy to explain and which do not depend on size or on habits, and of which the young show no trace. Thus gnus are much more dangerous and ready to attack their keepers than are elands, wild sheep are more combative than wild goats, and some of the small gazelles and small deer are quite savage.

I have little personal experience of young rodents except of pet rabbits, which, like most boys, I used to keep, but these have been so debased by domestication that their qualities are not interesting. It is certain, however, that the young of all rodents are easily tamed, and everyone has seen or heard of tame rats and mice, hares, dormice, squirrels and so on. They recognise their owners, like to snuggle against them, to climb on them, and readily follow them about. They show in every way a willingness to accept from human beings the attentions they would naturally receive from their mothers. They belong to the set of animals which on the whole dislike being laid hold of, and which are disposed to bite anyone

who tries to grasp them, but are much more often willing to climb on an extended hand or leg. How long their tameness lasts it is difficult to say. We get a good many presented to the Zoological Gardens because they have begun to bite, but I suspect that in some cases it is merely because their owners do not pay sufficient attention to the natural disposition of which I have just spoken. We are too ready to treat all tame animals like young carnivores, which do not in the least object to be grasped and picked up and have no fear of being held: but most animals, although they do not forcibly resent such treatment when they are very young, cease to submit to it as they grow older.

Young insectivores such as moles, hedgehogs and shrews will attach themselves in a rather stupid mechanical way to persons who adopt them, and certainly like nestling in a warm hand, and understand being fed, but I do not know of any of them remaining really tame when they grow up. A hedgehog kept in a garden will become accustomed to the presence of human beings and will usually come to be fed, but even such animals stray if they are given the opportunity.

All the marsupial animals have a relatively low intelligence, and few of them in captivity do more than learn not to be afraid of visitors and keepers and to come to the bars to be fed. By the time they leave the mother's pouch permanently, they have the mental characters of the adult, and I do not know of any case where a very young marsupial has been removed from its mother and been brought up by hand. The larger kangaroos occasionally allow themselves to be handled, and some of the small nocturnal opossums and phalangers submit to such treatment in a sleepy, indifferent fashion.

Young animals born in captivity are no more easy to tame than those which have been taken from the mother in her native haunts. If they remain with the mother, they very often grow up even shyer and more intolerant of man than the mothers themselves. There is no inherited docility or tameness, and a general survey of the facts fully bears out my belief that the process of taming is almost entirely a transference to human beings of the confidence and affection

that a young animal would naturally give its mother. The process of domestication is different, and requires breeding a race of animals in captivity for many generations, and gradually weeding out those in which youthful tameness is replaced by the wild instincts of adult life, and so creating a strain with new and abnormal instincts.

Apart from whether or no it lasts after a young animal has grown up, the degree to which tameness can be carried depends on the natural habits of the animals concerned, on their intelligence and on their inborn instincts. Taming should be no more than taking advantage of the natural instincts and guiding them in a slightly new direction. It is quite true that animals of high intelligence can be trained to do many things entirely outside their natural range. If the animals have good memories and their trainer use punishment freely, he can produce remarkable results, but I cannot understand how persons who think that they are fond of animals can endure seeing most of these tricks. A chimpanzee in evening-dress, lighting a cigarette and drinking brandy-and-soda on a music-hall stage is a shameful abuse of man's power over the ape's docility. Lions, tigers and polar bears snarling in a pyramid, with the whip cracking and the iron bar and loaded pistol ready to the hand of their trainer, can amuse only very stupid people, and the performance is probably less dangerous than sword-swallowing.

CHAPTER XIV

THE PURPOSE OF YOUTH

THE period of childhood or youth is peculiar to the living world and occurs, in the first place, merely because most living things do not come into existence as fully formed creatures like their parents, but as little specks of living matter much more like the earliest forms of life that existed. It has taken countless centuries for the living species of animals and plants to evolve from the primitive forms of living beings, and yet in each generation each new individual has to repeat the prodigious process of changing from the minute cell known as the egg-cell, which is separated from the tissues of its parent, to the complicated adult body, often composed of myriads of cells, with different structures and functions, and built up into the elaborate architecture of the adult. That these changes should happen at all seems so miraculous that perhaps it would not be more surprising if they happened instantaneously. It may be unphilosophical to expect it, but at least it is more comfortable to our intelligence that the growth of the individual does take time. When the details of the process are studied minutely, they are found to be gradual and orderly; the initial piece of living matter grows and divides, and the daughter-pieces divide, much in the manner of free-living cells which are not going to transform themselves into more complicated creatures. The first set of daughter-cells becomes arranged in a fashion closely resembling the structure of simple, living creatures which do not proceed beyond such a stage, and so, step by step, with at each step a memory more or less definite of some free-living creature that proceeds no farther, the final complication of the new-born or new-hatched young is reached. And so we come to see at least without surprise, if with less real understanding than we are philosophically justified in claiming, that living things pass through a period of childhood or

youth, and that that period is filled with memories of ancestral history.

In the development of many animals these memories of the past, in embryonic and in larval stages, and in the period of youth, are sometimes so precise and definite that they seem to give a clear picture of at least part of the ancestral history. Such instances are most common in the lower animals and in the lower members of the higher classes. They tend to be blurred and condensed, or omitted altogether. It seems, in fact, as if the first object of nature were to get rid of evidence of past evolution, and to hurry through each new creature as quickly and directly as possible to its adult form.

Youth is a perilous time in the life of animals. The young things, with their imperfect organs, with their relics of stages that were fitted to the environment of a remote ancestor, but are out of gear with existing conditions, are hampered with the cumbrous scaffolding of the past and can offer feeble resistance to accidents and diseases. They are a ready prey for a world of hungry enemies. It is in the first place imperative that this period of feebleness should be passed through as quickly as possible. And evidence of a tendency to shorten and simplify the development of the embryo or of the larva, to remove all stages that have ceased to be useful and to make straight the path from egg to adult is to be found in every group of the animal kingdom, but is increasingly plain in the higher groups and the higher members of every group.

The shortening and simplification are most complete in the embryonic stages of development, whether these take place within an eggshell or in the body of the mother. In free-living larvæ, or in active young, protection is often obtained by new organs, special habits, peculiar pattern and coloration that may have no reference to the past history of the animal and no direct bearing on its adult shape and form. Larval organs, habits and coloration are not infrequently new interpolations in the life-history, the sole purpose of which is to protect the larvæ and give them a chance of coming to maturity. The physical characters of youth are sternly economic. Special organs, new or old, are present because

they make it more possible for the creatures to escape the destruction that is always treading on the heels of the young. Pattern and coloration are either simply the ancestral garb of the parents still retained, or the direct results of growth, or occasionally, and especially in caterpillars, devices for the immediate protection of the young. The youth of most animals is too hampered by the past, too harassed by the present, for experiment in structure or coloration to be possible.

The amazingly heavy mortality that presses on the young is met in a great many cases by the enormous size of the families. I have given instances of the almost incredible number of eggs that are laid, of young animals that are turned adrift, a few of which escape the perils that beset them and live to maintain the species. This spendthrift fashion of reproduction is gradually replaced by a new method The number of the young is very greatly reduced, and the small families are protected by the parents Sometimes the eggs are retained in the body of the mother until they are nearly ready to hatch; sometimes they hatch within her body and are fed from her blood, sometimes even the eggshell is dispensed with, and from the earliest appearance of the embryo as a separate speck of living matter it is fed from the blood of the mother. The eggs may be laid in places carefully prepared by the mother or by both parents, and eggs and young may be fed and guarded for long. The young, even if born in an active condition, may be fed and protected by the parents for years or months. Instead of hundreds of thousands of helpless young dumped on a careless and hostile world, a very small number, sometimes only a single individual, is produced at a time and cared for in the most complete fashion.

In the highest animals, and especially in mammals, the young are freed from the trouble of finding their own food; they have very seldom to defend themselves, and the changes from egg to embryo and from embryo to adult are made as simple and direct as possible, and none the less the duration of the period of youth increases as we go up the scale of animal life. This lengthening of youth is specially plain when we compare the different members of a single group. If we

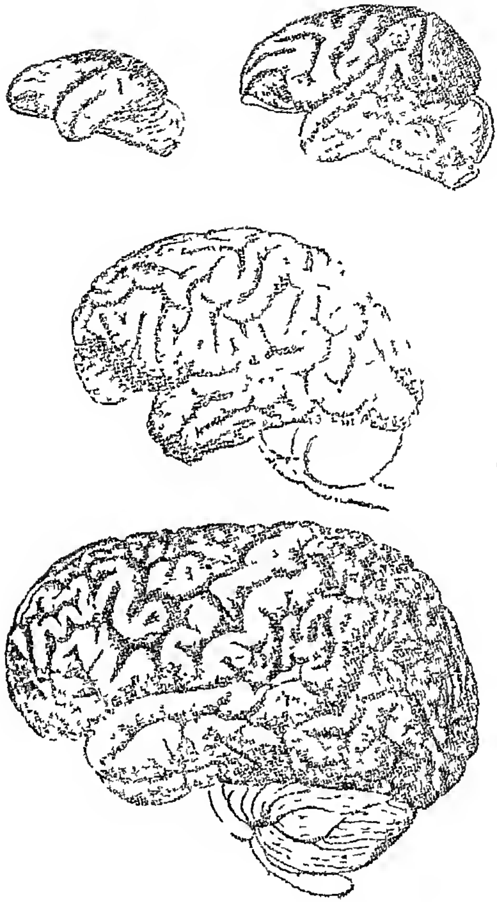


FIG. 32. Brains of Primates. The largest (lowest figure) is human; next, that of a chimpanzee; next (uppermost right) that of a macaque monkey; next (uppermost left), that of a cebus monkey. (The figures are all reduced to the same scale.)

take the human race and its allies, the apes, monkeys and lemurs, then man, who is at the top of the scale, has the longest youth, and even in the lower and less civilised races it would be unsafe to assign less than fifteen years to immaturity, whilst in the higher and more civilised types it is still longer. The great apes, the gorilla, orang and chimpanzee, take from eight to twelve years to grow up. The baboons and common monkeys take from three to eight years, and the little South American monkeys and lemurs require only two to three years. If we take weight or stature of the body, the strength of the muscles or any of the purely physical qualities, we shall find that they do not fit this varying scale of youth. There is only one part of the body that can be reconciled with it—the brain.

If we compare the contour of the brain in certain of the primates (Fig. 32), it will be seen at once that man, with the longest period of youth, has the largest brain; that although a chimpanzee may equal or exceed a man in size and weight, its brain is much smaller; and that the brain of a macaque is still smaller, but larger than that of a cebus monkey.

But there is a more important consideration even than size. The cerebrum, the great mass of the brain that fills most of the hollow of the skull, is smooth in the lowest forms save for a few faint wrinkles, which become more conspicuous and more numerous successively in the cebus, macaque and chimpanzee, until they attain the high complexity shown in the human brain. The correspondence is so close that we may say almost definitely that, at least inside the great groups of mammals, the length of the period of youth increases with the size and complexity of the brain.

I am not going to discuss here whether the brain be an organ of the mind, played on by some immaterial entity, as a musician plays on a musical instrument, or whether mental qualities be emanations of the brain as bile is a secretion of the liver. It is enough that the mental powers are definitely associated with the grey matter, and that their development and education write a record upon it. The grey matter contains the nerve-cells of the brain. A fully developed nerve-

cell may be compared with a spider seated in the centre of a web which is an actual set of outgrowths from itself. Some of the fibres of the web are in connection with nerves; indeed, there are continuous fibres from the cells in the brain to the remotest tissues of the body. Other fibres are continued to the web-fibres of other brain-spiders. The system might be compared with a very complicated set of telephone exchanges, each exchange supplying a certain district near at hand or far away, and each linked up with a number of other exchanges with their districts. The greater the number of subscribers' wires to each exchange and the greater the number of connections with other exchanges, the more perfect the system would be.

In the new-born mammal large numbers of the brain-cells lie isolated and quiescent in the grey matter; they are joined up neither to each other nor to distant parts of the body. In early infancy the brain has little or no control over even the chief muscles and tissues of the body. This is probably the explanation of a famous observation much written about some years ago. It is known that at least some very young infants will seize firmly any object which they can grasp. If one be given a broom-handle of which to lay hold, it will swing from this by one hand or by both hands, and even, by bending the muscles of the arms, pull itself up. When a little older an infant is unable to do this. The suggestion was that in its extreme infancy the young human being showed this sign of its monkey ancestry and swung from the broom-handle as an ape would swing from the branch of a tree. The objection was taken to such an interpretation that the action of the young infant was purely automatic, that its brain-cells were not yet joined up to the lower centres which control the automatic movements of the body. The young infant is a brainless creature, because the nerve-cells of its cerebrum are not yet linked up with the rest of the body. On this view, however, the comparison really becomes more interesting. The infant swinging from the broomstick is not acting like full-grown apes, but like young apes clinging to their mother. A new-born leopard, or mole, or hedgehog would not cling to a broomstick in this way, but a new-born ape

or monkey does so. There are many cases in the adult life of human beings where the higher cells or some of them are temporarily thrown out of action, so that they are in the same position as if they had ceased to be joined up. And in such cases the behaviour of the patient recalls that of apes and monkeys. When a normal healthy human being is struggling or fighting with persons trying to seize him, he uses only a small part of his muscular power, because the higher centres of the brain are interfering and warning him that he has to take care of himself, to avoid being hurt and even to avoid hurting his opponents too much. But if he be mad, if some of the higher brain-cells are temporarily put out of action, then he loses all restraint, and fights, as a desperate animal fights, without any thought of his own safety, and so exercises much more than his ordinary strength.

The period of youth in mammals is the time when the brain-cells of the superficial grey matter increase in size, throw out fibres, and come into more and more complex connection with each other and with the different systems of the body. Just as the number of these cells forms an index of the natural endowment of an animal, so the extent to which these interconnections are developed is a measure of the effect of education, in the widest sense of the word. No doubt a certain amount of development of these cells takes place throughout the whole period of life, particularly in the higher and more intelligent animals. But even in human beings, at least in average cases, there appears to be comparatively little further change in female brains after the age of fifteen, and in male brains after that of twenty-four or twenty-five. In animals, which after they have come to maturity seldom change the character of their experiences or of their abilities much, it is probable that the growth of the processes of the brain-cells practically is limited to the period of youth. We may in fact say more definitely that the period of youth is necessary for and is occupied by the co-ordination of the brain-cells of the grey matter and the development of a greater complexity of the intercommunications of these.

We are on safer ground, however, when we turn from the physical mechanism of the mind to the mental qualities them-

selves, and consider the effect of education on these, without too nice an inquiry as to what is education of the body and what is education of the mental qualities. We like to think that animals have instinct and that we have intelligence, but the passage from one to the other is gradual. All instinct can be modified to a certain extent by experience, and there remains a strong instinctive side in intelligence. The period of youth is the time when instinct is gradually broken down and replaced by experimental action.

Let us get the matter clear by some examples of undoubted instinct. A caterpillar is developed from an egg laid on a leaf. It has never seen its mother. It has never done anything all through its life, except eat when it was hungry (and that was most of the time), crawl under the leaf when it rained, come out again and resume eating when it was dry, and, perhaps, when it was startled, drop suddenly down, spinning a thread of silk, by which it re-ascended after a time Suddenly, and once only in its lifetime, it completely changes its habits. It spins silk without having been disturbed, rolls itself up in a leaf and fastens the edges of this blanket with threads of silk. All the caterpillars in the same brood do this exactly in the same way and almost exactly at the same time. They either accomplish their task correctly or bungle it completely. There is no question of practice, or imitation, or of learning. The necessary act is accomplished once and for all. When I was at Oxford, I used to keep common garden spiders in a cage, and found that when they were provided with twigs and proper surfaces to which they could attach the anchoring spokes of their webs, they spun these always exactly in the same way, and that in watching them the action seemed so orderly and was so completely fitted for its object that it was difficult not to think of it as intelligent. But one of the spiders, placed under an inverted bell-jar to which the threads would not remain fastened, quite contentedly went through the exact routine of operations for making a web, although the result was a meaningless wisp of threads. A chick that has been blinded by covering its eyes with a hood almost before it has got out of the shell, and that is kept blindfolded and fed by hand for a day or

two until it is strong, will peck at objects unerringly as soon as it is allowed to see them, although it will not at once distinguish between food and stones. My caracal cub was taken from its mother when it was just able to see, and not nearly strong enough to stand upright on its legs. It was born very early in the year, in what turned out to be a cold spring, and for at least three months it had no opportunity of seeing either another caracal, or even any kind of cat. It lived entirely with human beings. It was accustomed to be washed and brushed carefully, and yet as soon as it was strong enough, it began to lick its own paws, to wet them and use them to wash its face, precisely in the fashion of its parents and of all their ancestors and of the whole tribe of cats from time immemorial. It is easy to misinterpret instincts and to think of them as intelligent, or as meaning more than they do.

Instincts, whether they are complicated, like the spinning of a web, or simple, like the sudden response to a disturbance, have not to be learned and imply neither intelligence nor consciousness. They either fit a very precise set of conditions, and if these are not present they break down, or they are so vague and generalised that they are not easy to distinguish from processes with which the brain has nothing to do. If an unpleasant substance such as an acid be applied to the leg of a frog, it will pull the leg away; if the leg be held, it will apply the other leg to the affected spot, and try to rub the acid off. Such behaviour we certainly regard as a simple kind of protective instinct, but, as it takes place as precisely in a frog which has had its cerebrum destroyed as in an undamaged animal, probably all such instincts are combinations, more or less complicated, of the direct physical responses to stimulation which living matter displays. To analyse them into their constituent parts is a kind of vital chemistry still beyond our power.

A few examples of some of the simpler elements out of which the instincts are combined may make this difficult subject clearer. They are what are known as tropisms, tendencies to turn towards, or to turn away from, the source of physical stimulation, and are found in all kinds of living

matter, animal or vegetable. They may be traced upwards to the most highly developed of living beings, including ourselves, although in these latter they may be disguised or controlled by the higher nerve-centres. The reaction to light is known as phototropism or phototaxis. Many free-living cells, especially the swarm-spores of plants, diatoms, and even many colourless animal and vegetable organisms, move in the direction of illumination, if the light be not too strong, but on over-stimulation may move away from it. Other small organisms move away from light towards darkness under all circumstances. From these simple reactions, we pass by easy transitions to the much more complicated and yet more precise actions of the higher animals with eyes and with definite nervous systems. Turn up a stone on the seashore or a log of wood in a garden, and you will see numberless little creatures disturbed by their exposure to light and at once setting about wriggling, creeping or running until they can get to darkness again. The reaction begins before there is any tracc of a definite mechanism to produce it, and is continued up to those animals to which even persons least inclined to assent to the existence of consciousness in all living matter are quite ready to attribute some form of consciousness. Very low in the series, too, we see the simple reaction changing with the state of the creature to which it is applied, the turning towards light, for instance, being reversed to a turning away from it when the stimulation reaches a certain degree of intensity. And so long before the dawn of consciousness, unless the term consciousness be so attenuated as to be meaningless, we get a beginning of adaptive response.

The contact tropisms are other factors of instinct at first extremely simple. A free-swimming, single-celled creature, animal or plant, which comes in contact with an obstacle, responds in some way. It may shrink back, sometimes with a little turning movement, and advance again, and it may proceed by this system of trial and error until it finds a way round. On the other hand, if an amœba come across a solid surface, it at once creeps out over it, for it is the habit of that creature to creep in contact with any flattened surface, instead of drifting freely in the mud or water A growing

rootlet burrows into every crevice, whilst a shoot moves in the direction of free space and air. As we ascend the scale of the animal kingdom, we find numberless creatures, low and high, which exhibit such a choice with regard to surfaces. The stems of polyps grown in a glass tank cling closely to the walls of the vessel, but their upper portions, carrying the mouth and tentacles, turn outwards towards the open space. Free-swimming larvæ wriggle out of a crevice if they drift into it. Most marine worms move about restlessly until they have an opportunity of burrowing into sand, or of creeping into some chink in the rocks. A very large number of insects, from cockroaches to ants, and whether they are exposed to light or kept in the dark, will move about restlessly until they can squeeze between the folds of a sheet of paper, or into some similar place where they are in contact with a surface all round. In an aquarium, pieces of drain-pipe have to be placed for many different kinds of fish, such as eels and pike, whilst others become restless if they are enclosed in such a fashion. So also amongst reptiles, there are some which must be provided with retreats into which they can creep, others which like to lie in the open. Amongst mammals there are some that cannot be persuaded to enter any box or chamber if it appear to be closed. Deer, antelopes, cattle and sheep and most of the large carnivores can be boxed only with the greatest trouble, sometimes by the device of making the box apparently a narrow tunnel open at the end turned away from the entrance. Such animals often damage themselves seriously in their endeavour to escape from a closed chamber, but will be comparatively content if at least one of the sides is protected by light bars. Another set of mammals, of which the small rodents are the best-known instances, at once enter any little hole or aperture and lie placidly in a closed chamber. In higher animals these contact reactions naturally are modified by other factors, such as positive and negative phototropisms, and they are affected by mental factors, but none the less they are linked up with the simplest responses given by single-celled organisms. Traces of them survive even in man. In nervous subjects the condition of claustrophobia is well known. Persons

affected by it have an almost hysterical dread of closed spaces. They will hesitate to enter a very small room, to go down a narrow alley, to sit in the middle of a row at the theatre, to ride in a closed carriage. Victims of the opposite tendency are said to be affected with agoraphobia. They have a fear of open spaces, will go round two sides of a square rather than cross the open place, are happier in a crowd, prefer a closed carriage and so on.

Chemotropisms, or attraction to or repulsions from chemical stimulation, occur not only in free-living cells but in the separate cells and every part of the tissues of higher animals and plants. Some microbes move towards a supply of oxygen, others away from it, so that where such are mixed in a drop of water under the microscope they will quickly arrange themselves in a pattern, one set crowded in the centre, the other round the edges where the water is in contact with the air. Weak alcohol repels most free-living cells, weak acid attracts them. Some will move towards solutions of sugar, others towards meat-juice diffusing in the water. The meeting of the sexual cells, the attraction of food, the senses of taste and of smell are all cases in which chemotropism plays an important part.

I have given only a few simple instances of these fundamental reactions of living matter. They occur at first without any of the complicated bodily machinery through which they act in the higher forms of life. They are not rigid like the actions and reactions between bodies of matter that are not alive, for the living matter is constantly changing and almost from moment to moment may behave differently with regard to the same stimulus. They do not occur separately and independently, but in all the higher forms they are combined in varying degrees. But without doubt they are, so to say, the raw materials or uncombined elements of the instincts.

These various factors of instinct can be modified by experience. In a few cases the same response is repeated to each application of the stimulus, but it is far more usual for a change in the response to take place, the duration of the change increasing in the higher animals until it passes into what can be called memory. An infusorian animalcule will

go on bumping up against an obstacle indefinitely, at each contact recoiling, twisting over and charging again, and it is mere luck if in a series of movements of this kind it finally discovers a way round. A worm similarly confronted with an obstacle behaves practically in the same way, but it gets more and more excited in its movements, and may finally get round by some violent contortion, more or less in the fashion that a man reading a book will, from time to time, simply put up his hand to push away a persistent blue-bottle, but at last will get out of his chair and hunt it round the room. In the latter case, however, in addition to the summation of the irritating effect of the stimulus, the higher parts of the man's brain come into play, and he ceases to be merely instinctive. It is the natural instinct of a spider to drop from its web at any sudden vibration, or when a shadow is thrown on it. Mr. and Mrs. Peckham, experimenting with spiders, found that they would drop when a tuning-fork was sounded near them, but that after fifteen times they ceased to take any notice of the disturbance. Even extremely simple creatures which live attached to a surface by a contractile stem and shrink up to their support when they are touched soon fail to respond to a repeated stimulus. The infusorian *Vorticella*, the polyp *Hydra*, behave in this way, and a sea-anemone which at first contracts its tentacles when they are touched will very quickly cease to respond. So also single-celled creatures become accustomed to, and may even reverse their response to weak chemical stimulation; instead of withdrawing from alcohol, they may move towards it. When the chemical tropism is a response to a food substance, it may cease when the animal is satiated, to be resumed later on, and this may mean no more than a change of chemical interaction due to the changed condition of the fully fed organism.

There is no doubt but that the effect of the stimulus can be modified or reversed by repetition in all the simpler cases that have been tried. These results, however, wear off very quickly in the case of single-celled creatures and the simpler animals, and after a lapse of time, which may be measured in minutes, hours or days, the normal responses to the stimulus are

resumed. We may suppose the protoplasm and the very simple mechanisms of muscle and nerve concerned to recover from the fatigue or strain, or abnormal chemical condition, into which they have been thrown, and on their recovery to be practically, perhaps completely, unaltered. It is different, however, with higher animals, where there seems to be a power of registration of the effects of experience, a registration that becomes not only more complete but more easily available in vertebrates than in other animals, and in the higher vertebrates than in the lower vertebrates. The organic mechanism itself consists of a simple form of sensitive organ to receive the stimulation, nerves to transmit the message to a group of nerve-cells which again directly or indirectly control a group of muscles to carry out the reaction. This mechanism may be permanently altered by experience, but, besides such alteration, the results of experience seem to be stored, so to say, in some separate receptacle. All physiological knowledge points to part of the grey matter on the surface of the brain as the storehouse, and it is precisely this region which becomes relatively larger and more complex in the higher vertebrates. What we must suppose to happen in those animals which possess this storehouse of experience is that when stimulation occurs it calls up or awakens not only the special mechanisms with which it is connected, but the reservoir of past experience. The resulting action is controlled not only by the mechanism, but by the effect on the mechanism of the stored experience. The name for this storehouse of experience is memory, so that what happens in the higher animals is that response to stimulus is increased, controlled or modified by the memory of past responses.

These high problems have taken us far away from instinct. Although what I believe to be the component parts of the instincts, the responses to stimulation, can be modified by experience, the more complicated and typical instincts are not modified by experience, and, indeed, many of them are called into play only once in the life of an individual. Nature has chosen another path for them. They have been built up in the long history of the race into very perfect mechanisms which admit of no alteration and of no blundering.

Given the appropriate conditions and the result follows. The animals are fully equipped to meet a certain set of circumstances, and if these present themselves, the adaptation between organism and environment is complete. If the proper environment does not present itself, the instinct cannot come into operation, and if it be necessary to the life of the animal, the animal dies. No doubt instincts vary, like every part of the animal organism, and in course of time, by a continuous rejection of the less suitable variations and a continuous preference of the more suitable variations, an instinct might change. But so far as the individual is concerned, the instinct is fixed.

The operation of an instinct requires, in proportion to its complexity, a certain complexity of structure, and until the latter has been attained it cannot take place. On the other hand, it does not require practice, and there is no reason why animals that rely upon instincts should have their period of youth longer than the time required for bodily growth and development. In the vertebrates, however, and especially and increasingly so in vertebrates with high brain development, the rigid instincts are being broken down and replaced by actions controlled by experience and by memory, and so fitting more varied circumstances and more varied environment. The period of youth is prolonged to afford time for this. The animals are protected and cared for by their parents, and allowed a space in which the burden of life does not press heavily upon them, and in this time they have to educate their instincts, destroy their rigidity, allow them to be controlled by the stored-up results of experiment. The purpose of youth is to give time for this, and therefore those animals which are most intelligent, which have the most complex brains, have the longest period of youth.

CHAPTER XV

EDUCATION

There is no complete separation between instinct and experimental action. The animals in which instinct rules come into their full powers at once, and have little or nothing to gain from experience. But the higher types of animals, those in which experimental action directed from the experience stored in the brain is the dominating feature of life, start with certain clearly marked aptitudes or tendencies which may be called instinctive. It is not merely because a carnivore has teeth and claws that it becomes a beast-of-prey, or because a duck has webbed feet that it begins to swim. In the slow process of evolution, the structure of different kinds of mammals has become so fitted to the kind of life they are going to lead that it is difficult for their machinery to work, so to speak, in any way but the way for which it is fitted. And part of the structure is the unconscious nervous mechanism which lies behind instinct, and which requires time for growth, but not necessarily time for training. But however definite may be the direction of aptitudes, most of these have to be educated by experiment and teaching, to adapt them to the varying circumstances to which they must be applied. The animals have to be initiated into life, they have to learn to use their bodies. The moment a may-fly has freed itself from its pupal case, it is able to crawl up on a dry bank, and the moment its wings have expanded under the influence of light and air, it flies off with as complete control of its powers as it will ever have during its short life. This is not so with most of the powers of the higher animals. They have to learn control over their own body and over their special kind of locomotion. Even when they are strong and active, young birds and mammals fly or run against obstacles, lose their balance, fail to stop in time or to turn quickly, and hurt themselves in many ways. The very flexi-

bility of their powers makes it more difficult to exercise them without practice. They have to acquire skill in obtaining their food, as well as knowledge of what that food is. To nibble grass, to gnaw roots, to strip fruit or leaves from trees require a certain amount of skill, and it is amusing to see how clumsily young animals usually set about these necessary tasks. When the food is a living prey that runs or jumps or turns on its enemy, even greater knowledge, skill and agility are required. The young animals have to learn to defend themselves by recognising danger, by hiding or escaping by swiftness, or by fighting.

Young birds and mammals differ very much in the difficulty they seem to have in acquiring their various forms of locomotion. Ducklings, even if they have been reared under a hen, take to the water at once and swim without any practice. Cygnets have to be coaxed or pushed into the water by their parents, and seem anxious to get out of it, either on the bank or by climbing on the backs of the adults. Young gulls avoid the water for a considerable time, but eventually are taken to it by their parents. The aquatic mammals, except, of course, whales, dolphins and porpoises, manatees and dugongs, are all born on land, and have to be coaxed or driven into the water by their parents, but as soon as they get there swim as instinctively as fishes or snakes.

The ancestors of birds were quadrupeds and no doubt walked on all fours like most living lizards. The front limbs have been transformed into wings, and birds are now purely bipeds, walking, hopping or running only on their hind-legs. This form of locomotion appears to be more difficult to learn than the quadrupedal gait of four-legged creatures. It is clear that the bipedal gait is a recent acquisition, and traces of the older form of walking are seen not only in the structure of young birds, but in the difficulty which they have in learning to walk.

Little quadrupeds find it easy to walk as soon as their legs are strong enough to support them. Young kangaroos, when they begin to come out of the pouch, use their front paws a great deal in walking, and only gradually acquire the hopping gait of the adult. Most monkeys are really quadrupeds in

gait, and when they are running fast on the ground, gallop on all fours. Human children, of course, begin to crawl on all fours and learn to walk only with much difficulty and with a good deal of persuasion and help.

The difficulty which bipeds have in learning to walk is thus due to a double cause. In the first place the action, like most of the actions of the higher animals, is not purely an instinct, but the complex balancings and the varied movements are learned partly by experience. In the next place, it is a comparatively recent acquisition of the race, and the structure still contains many elements which are not yet completely adapted to it.

Learning to fly is a still more difficult task. Young swallows are said to fly without any teaching or persuasion, and it may be that these, which are, perhaps, the most completely aerial of birds, have reached a stage which most birds are only on the way to reach. In most cases, the mothers have to use persuasion or force, and to protect the fledglings from hurting themselves in their first efforts. Sparrows may be seen tempting their young into the air by offering them food and then flying off a little distance before it has been taken. The mother stork pushes the young birds off the edge of the nest or chimney-stack on which they have been resting. Most of the birds-of-prey and many of the perching and singing birds push their young off a support and then hurriedly fly under them to break their fall. Even after the first fluttering movements have been made, young birds take weeks or months before they acquire perfect control, before they can turn in the air, alight suddenly on a branch or even on the ground, and certainly before they can readily launch themselves into the air from the ground.

The process of learning to eat shows an intimate blending of instinct and experience in both birds and mammals. The instinctive part resides chiefly in the senses of taste and smell, and the part that comes by experience is the association of appearance with edible qualities. But the matter is further complicated by the fact that many young birds and mammals are fed by their parents and would otherwise starve in the midst of plenty. In the case of birds, those that are hatched

in an active condition generally pick up their own food almost at once. At first they peck at everything, taking stones, grains, fragments of vegetation, insects or pieces of flesh, but very soon select only vegetable matter if they are eaters of plants, different kinds of material if they are omnivorous, or grubs, insects, fish or flesh if they are carnivorous. The carnivorous young birds do not seem to have any strongly marked choice between fish and flesh. A good many of the active young birds are assisted by their parents, either by food being brought to them, or disgorged in front of them, and these when they are left to themselves will pick up food, but will die rather than hunt for it. They learn only slowly that food may be edible even although it is not brought by the parent. All the birds in the mouths of which the parents place the food take a very long time to associate the appearance of food with the idea of eating. If substances are actually placed in their mouths, they instinctively swallow them, but reject them if they are unsuitable, and soon learn to do so without having swallowed them. On the other hand, hungry young birds, large enough to be able to hop on the branches or even on the ground, will shriek for food with their bills gaping widely, although attractive worms are wriggling and squirming within an inch of their nose and eyes.

There is much the same set of differences amongst young mammals. The act of suckling seems to be purely instinctive and takes place as soon as the little creature finds the warm nipple. An artificial teat arouses the instinctive action nearly as well as the natural organ, and young mammals take readily to the bottle. But if the liquid supplied be cold, or very different in flavour from milk, the reflexes do not work and the material is not swallowed. When the milk diet begins to be varied with other substances, there is an interplay of instinct with the results gained by experiment. The vegetarians will not attempt to nibble flesh or fish or living animals, but they take some time to learn the difference between grass and dry paper, and so forth. The sense of smell and that of taste are certainly present, but act at first only on acute differences and lead them to reject certain

substances rather than to show preferences amongst those that they will take. I do not think that there is any instinctive recognition of or rejection of poisonous plants; the young animals have good memories, and if a plant is unpleasant either to the sense of smell or still more to the palate, it is rejected after trial and not taken again.

Young mammals which naturally would have their food brought to them by their parents seem to have a very small amount of instinctive selection or rejection, and when they are brought up by hand will take very unsuitable food. This at least has the convenience that they are not at all difficult to get to feed when they are being brought up artificially, and will often live for a time on very erroneous diet.

Thus even in the simplest and most necessary parts of their activities, young birds and mammals do not spring fully equipped into life, but have to learn by trying. They have instincts, but these carry them only a little way. Few of them can walk or swim or fly without laborious practice, often aided by help or coercion from their parents. They have not full control even over their muscular powers, and there is not a proper adjustment of the co-ordination between eyesight and movement. They overbalance themselves, totter, outrun themselves, stumble and bump about, miscalculating distances, and are blundering creatures in an unfamiliar world, whilst the lower animals take up the game of life as if they were only renewing it after a sleep. At first sight, the advantage seems to rest with the animals guided and ruled by perfected instincts, but we have to remember that they are at the mercy of the chance of finding the right conditions and the right stimulations to awaken these instincts. If the conditions are wrong, the world is not merely strange, but forbidding, hostile, impossible, and they perish. The higher types, being less accurately adjusted to any particular environment, can become accustomed to a much wider range of environment. No conditions are quite right for them, but they can learn to make shift with almost any conditions in which they happen to find themselves. It is with this task of fitting themselves to the world that they occupy their youth, and it is for this task that they enjoy a prolonged

period of youth and a degree of freedom from the immediate cares of finding their own livelihood and protecting themselves against the dangers of the world.

The high spirits of young animals are proverbial. Not only young human beings, but young apes and monkeys, carnivores and herbivores, rodents and edentates, liberate an excess of vitality in the wildest antics. But it is to be noticed that this is not true of all young animals. Caterpillars, young cockroaches or grasshoppers, lobsters or crabs or snails are not to be distinguished from their seniors by any excessive gaiety. The exuberance of youth begins with the higher animals and increases as we ascend the scale of vertebrate life, precisely as parental care, intelligence and relative duration of youth increase. The high spirits of youth are part of the new order of things in which the period of youth is devoted to the replacement of instinctive action by experimental action.

The destructive habits of young animals are by no means specially marked in predaceous creatures, but are simply a part of the experimental curiosity of youth. Human children, until they have been laboriously taught to behave differently, pull to pieces everything they can get hold of, toys, dolls, implements of all kinds, and even such live animals as they are able to reach, using their teeth and fingers in the work of destructive exploration. Young monkeys behave exactly in the same way. They break all the toys that are given to them, tear their blankets, pick their bedding to pieces and scatter it about, spend almost inexhaustible patience in unravelling the wire of their cages, or in trying to open the doors or break the hinges, and, just like children, they can be taught, up to a certain point, to handle things more carefully and to refrain from breaking them in the presence of their keepers. But as soon as they are left alone, they resume their occupation. Puppies, the cubs of wolves and foxes, and kittens of every kind, colts, the fawns of deer and antelopes, calves and kids, and even young elephants show the same restless exploring energy. Some birds, such as parrots and cockatoos, remain mischievous and destructive all their lives. But most birds in their youth have similar

instincts, and often cause their parents much labour in repairing the damage they do to the nest.

Much of the experimental activity of the young, and especially that shown in games, is not random, but is defined and directed by their structure and instincts. Professor Groos has shown that the games of young animals bear a definite relation to their future life; he has extended to other mammals the application of the saying that the battle of Waterloo was won on the playing fields of Eton. Animals that have to escape or to catch their prey by swiftness and dexterity rush madly in circles, or race each other until they have to lie down from exhaustion. Goats, sheep and chamois are mountainous, rock-loving animals, accustomed to make high vertical jumps from one ledge to another. Their kids and lambs practise high jumps with an effect that is ludicrous when we see them on flat ground suddenly springing into the air. Rocky-mountain goats are said to be the most sure-footed of all animals; they are slow and deliberate in their movements, creeping along almost invisible ledges on the face of precipitous cliffs. Their kids show the same stealthy and careful movement, climbing to the roof of their shelter, not by sudden jumps, but almost inch by inch. Gazelles and antelopes which inhabit open plains practise long jumps when they are young. Young dogs and wolves run round and round in circles trying to head each other off. Most of the smaller cats are accustomed to take almost vertical high jumps; domestic kittens can be seen to make sudden leaps in the air almost like young goats; my tame caracal kitten used to stop suddenly when running, gather its legs together and make most comical vertical leaps in the air. Caracals in the wild state prey chiefly on birds, which they stalk until they flush them, and then leap in the air and catch them on the wing. I have seen an adult caracal in the Zoological Gardens stand under a shelf five feet above him, look up at it as if measuring it with his eye, and then reach it by a straight vertical jump without a run. Climbing animals, when they are young, practise climbing assiduously. My tame hyrax, almost day by day, found some new feat to attempt, and kept trying until it succeeded. One of its first serious experiments

was to climb the smooth leg of an iron bedstead, which it did at first rather clumsily, choosing after many vain efforts the leg that stood in a corner, and getting up by pressing its back against the angle of the wall and its feet against the iron rod, much in the fashion that a mountain climber ascends a "chimney." It soon became perfect in this method of reaching the bed, and then proceeded to acquire the art of swarming up the more difficult legs where there was no wall to help. The smooth leg of a mahogany chair was then mastered. The polished rails of a hot-water towel stand took a longer time, but the little animal persevered until it had learned to climb the vertical bars and walk along each of the horizontal bars, and finally to swing down from one horizontal bar to another. One evening it discovered that it was possible to ascend the vertical moulding that surrounded a door. The moulding was about four inches across and projected an inch and a half from the wall. The hyrax straddled this, pressing against the projecting edges with the palms of its fore-paws and the soles of its feet, and got a good way up in a series of little jumps. Its usual method of descending a pipe was to turn round and come down head foremost, which was impossible in this case. It suddenly stopped and shrieked until I came and helped it down. It then at once made a second attempt, I standing near; when it got near the top, it turned round as if to see that help was at hand, and then slowly slid down backwards, refusing any assistance. When it found that it was possible to get down safely, it tried again and again, until at the fifth attempt it reached the top of the door, where it could turn round and come down in the way it preferred. A lesson once acquired was never forgotten; after finding out how to master a difficulty, the animal never bungled. Similar observations have been made on many young animals, but particularly in domestic animals. In the case of the hyrax there was no possible taint of ancestral modification by domestication, as its ancestors from time immemorial had lived in the high tree-tops of Nigeria. I have said a good deal about it because it shows admirably the fundamental difference between the instinctive and the experimental types of action, and the

great advantage that those animals enjoy which have the power of fitting their natural capacities to any strange environment in which they may come to be placed.

The games of young carnivores have a direct bearing on the catching of a living prey. A kitten's play with a reel, patting it, making it roll to a distance and then springing on it, like the game of the mother with a real mouse, is a method of training the eye and muscles for the important business of catching dinner. The natural instinct for such games is inborn, but the capacities have to be trained. The mother of wild carnivores gives her kittens or cubs the tip of her tail as a toy, making it quiver to attract their attention, flicking it away from them and tempting them to spring on it. My caracal kitten, which had been removed from its mother long before it was old enough to play, amused itself with a reel and a ball exactly like a domestic kitten.

Many of the games of young animals are preparations for fighting. Kids, lambs and calves butt and engage in endless mimic combats. Deer stand up on their hind-legs and fight with their fore-legs. Young donkeys, horses and zebras dash at one another, rearing and striking with their heads and fore-legs. All the young carnivores romp and tussle with each other. Puppies try to seize their friendly enemy by the throat, to roll it over and to hold it down; the vanquished animal lies on its back and strikes out with its fore-paws. Young lions, tigers, cats of all kinds and young bears wrestle and struggle with each other, sometimes biting rather severely. When young carnivores are playing too roughly with their mother, she teaches them a lesson by cuffing them, but I have never seen her interfering to stop a quarrel in her family, and not infrequently a good deal of damage is done as the excitement of the game passes over into reality. When young animals are beginning to take pleasure in their strength, it is important that they should have plenty of room and a diversified open space in which to run about. They then work off much of their surplus energy in chasing each other, and are less disposed to fight to a finish. But even under natural conditions, usually one or two of the weaker cubs are killed in these experimental trials of strength.

Perhaps the most interesting and distinctive feature of the higher animals when they are young is their faculty of attention. A sudden sound, a moving object, a vibration of the soil or the surface on which they are placed at once arrest their attention. They stop chewing or drinking, even if they are hungry or thirsty, cock their ears, turn their eyes in the direction from which the disturbance seems to be coming, and you see that every sense is on the alert. Then some process takes place which if it were in a human being we should associate with memory and judgment The disturbance is recognised as something not worth troubling about, and the occupation is resumed, or it is followed by some action, of retreat or of preparation for aggression. These successive actions take place whether they are accompanied by some dim mental phase corresponding in a faint way to our conscious judgment, or whether they are like the unconscious action of a sleep-walker. Adult animals generally decide at once as to whether an event which has engaged their attention is of a kind to neglect or of a kind requiring action. They do not show much curiosity, but, right or wrong, abide by their decision and proceed with the business in hand. They have stored up enough experience and have no special wish to learn anything new. Young animals, on the other hand, are intensely curious, and the process by which they fit themselves to their environment can be watched. My hyrax was at first much disturbed by the sound of a clock in my room, which chimes the quarters and strikes the hours. At first it would stop whatever it was doing when the sound began, letting even a piece of its favourite ice-wafer drop from its mouth; then it became accustomed to the sound and now just stops for a second and resumes at once. I have tried it with other striking clocks, and it seems to have classified all of them as harmless. With the telephone bell it acts differently, rushing across the room to the telephone table, climbing up to the instrument and waiting there for me. I have tried it with an alarm clock, the sound of which is much like that of a telephone bell, and it at once accepted that as one of the things to be run to.

Curiosity, attention and memory do much for the educa-

tion of young animals, but the very strange faculty of imitation also plays its part. I do not know of any term used of animals that is more difficult to understand or to apply justly. The chief difficulty is that we are disposed to interpret the actions of animals too much in the same fashion as those of human beings, and to suppose the presence of a conscious factor which may not exist. When we speak of imitation in human beings, we think of the imitator as forming an idea suggesting corresponding action on his own account. It would be going very far indeed to assert such a mental process in the case of animals. Many cases that are sometimes set down to imitation are no more than instances of similar vital machines responding in the same way to the same stimulus. A kitten washes itself or plays with a ball precisely in the same fashion whether it has been brought up by its mother with its brothers and sisters, or has been reared away from all other cats. Animals left to themselves gain the same lessons from the same experiences that they would have learnt in association with their kind. The fact that so many young animals follow their mother accounts for many of the circumstances that look like imitation. When she runs, they run after her, and it is only by experience that they learn to associate with running the stimulus that made the mother run. They run, not because they are imitating her action, but because it is their habit to run after her. So also when she leads them to the proper food, and they follow her example by eating it, all that it is necessary to suppose has happened is that the food stimulus to which they have been led excites them to the same action as it excites their mother. Nor does the common action of gregarious animals really imply imitation. The playful stampedes of cattle, the game of "follow my leader" indulged in by sheep and goats and antelopes, the migrations of mammals and birds do not necessarily mean more than similar response to similar stimulation.

Nevertheless there are many facts which make it difficult to doubt that the higher animals, especially when they are young, perform actions, consciously or unconsciously, because they have just been performed by other animals or by human

beings. I do not think that this happens whilst the young creatures are quite infantile, but only after the period which is well described as "beginning to take notice." The action must be more or less like one that the animal would naturally do, or if it be complicated, it must be built up step by step out of separate actions which are not too unfamiliar or incongruous with natural habits. I picture, rather than explain, the process to myself by supposing that in animals with well-developed grey matter in the brain actions write some sort of record of themselves in the brain, apart from the necessary reflex brain-and-muscle mechanism by which they are controlled. This record can be excited in various ways, and its excitement may set going the actual mechanism. When the young animal's attention and curiosity are aroused by the action of another animal, the records already stored in its brain are awakened, and the most closely corresponding reflex mechanisms are "called up" and set going. Consciousness is not necessarily involved, but the process is a result of organic memory.

However it be explained, action which is the result of a corresponding action becomes increasingly important in the higher animals. Wild animals acquire or at least perfect many of their capacities in this way. The process of taming and training animals is based on it. How far birds learn from one another or from their elders I do not know, and it is a much-disputed question. It seems to be fairly certain that building of nests does not come about by any process that may be called imitation, and that birds reared by hand or away from their allies will in due course build according to the pattern of their kind, although their first attempts may not be so good as later efforts. The ordinary call-notes and narrow range of voice that occur in most of the families of birds are similarly inborn, but the higher and more complicated kinds of song certainly owe much to practice and emulation. Singing birds that are reared away from their kind achieve only a feeble and halting song, but rapidly acquire elaboration and richness when they hear others singing.

With mammals we owe kinship in every fibre of our bodies

and we can establish relations with them in many different ways. Their senses of smell, taste, touch, sight and hearing, their muscular movements and reflexes, their passions and their pleasures, the instincts with which they start life and their mode of modifying them, are all like our own. This very similarity makes it difficult not to confuse between real imitation and corresponding action in corresponding circumstances. There seems no conceivable doubt about imitation, however, in the case of man and the great apes. Chimpanzees and orangs watch what is happening round about them. If you take a wooden match-box out of your pocket and open and shut it, and then give it to one of them, it will try to repeat the movement. They copy their keeper in sweeping out their cage. They are taught many kinds of tricks and performances almost as much by doing the various motions required in front of them as by actually guiding them. They will run when you run, dance when you dance, shoot out their lips and scream when you set them the example. No doubt there is a pitfall even here. Monkeys are, as it were, caricatures of human beings; in a sense they ape man, although they may never have seen him. I am convinced, however, that they constantly perform new actions because similar actions have been carried out in their sight, and I find it difficult to avoid the belief that the anthropoid apes at least have some dim consciousness of what they are about. Notwithstanding the innumerable anecdotes about the intelligence of other mammals, and the great difficulty there is in describing or even thinking over one's own personal experience in taming and training animals without slipping into language that implies conscious imitation, I do not think that there is any real evidence for it outside the group of monkeys. Curiosity, attention and organic memory seem to me to account for all the facts, and it must be remembered that even the word curiosity is a dubious term. It may mean no more than that the senses are alert to any stimulation, and that stimulation is followed by action directed towards the source of the stimulus.

This may seem a doubtful end to an argument, and a cold conclusion for one who is a lover of animals. The trouble

lies in the word consciousness. In my opinion instincts, experimental action, experience, memory with its consequence —choice of motives for action, the immediate and the remembered—states of pleasure and pain, all may precede consciousness. Consciousness is something apart from them, different from them, probably dimly beginning in the lower animals, a little clearer in the apes, still clearer in savages, but even in ourselves intermittent, and at its best much less complete than we think.

If, however, we remember that the terms we employ must gain or lose colour and change their significance according to the extent to which we are willing to suppose consciousness involved, then there is no doubt about the facts. The reason why the higher animals have a long period of youth is that instinctive action may be replaced by action based on experience, upon the remembered results of experiment. For this purpose they are fed and protected, freed from the cares of the world and shielded from its troubles, dowered with an excess of energy and a fund of high spirits. When adult, independent life is reached, there is seldom time for reflection or experiment. The business of life is to meet a continuous series of emergencies by prompt and unhesitating action, and this is accomplished best by those animals that have had the longest youth, the best opportunity for playing at life whilst it was still a game, and for making mistakes when mistakes mattered least.

The mental field of youth and especially of our own youth is sometimes spoken of as a *tabula rasa,* a clean sheet upon which anything may be written. Nothing is farther from the truth. In young animals and in ourselves it is a blend of all sorts of inborn instincts and aptitudes, and we have gained the tremendous advantage over other animals and over the lower members of our own race, that we have a prolonged time for finding out and developing the aptitudes and for modifying the instincts. Our own youth should be devoted to this natural purpose. What is called technical education, the training for a special avocation, the development of an aptitude for a special calling, should be put off as long as possible. The infant prodigy, and the youth who

quickly finds out one thing that interests him and plods successfully at it, represent lower and older types, grades in the evolution of man which are being discarded. Youth should be spent in blunting every instinct, in awakening and stimulating every curiosity, in the gayest roving, in the wildest experiment. Education should be a parade of all handicrafts, of all mental and emotional stimulations, of the arts and sciences, and the last thing to be considered is what is practically useful. The supreme duty of youth is to try all things, to experiment with everything, to be scatter-brained rather than concentrated. In due time the world will certainly close round and press each beginner of life in one direction, but he will meet the pressure most successfully who has remained young longest and who has stored up the most varied experience.

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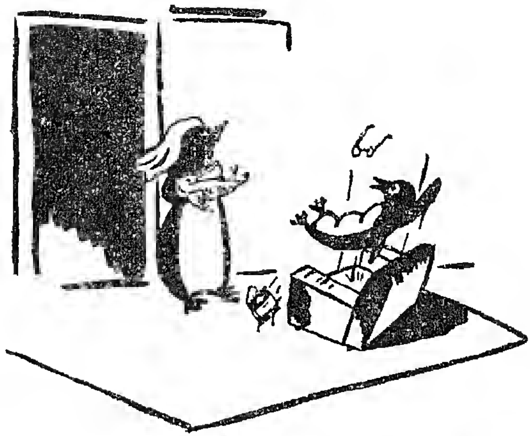

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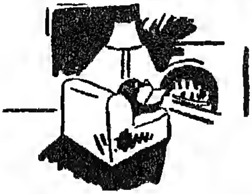

ARRANGED ALPHABETICALLY

For your leisure moments

Richard Aldington	*The Colonel's Daughter*	203
" Bartimeus "	*A Tall Ship*	103
Vicki Baum	*Helene*	194
Adrian Bell	*Corduroy*	247
Hilaire Belloc	*But Soft: We Are Observed*	189
Arnold Bennett	*Grand Babylon Hotel*	176
J. D. Beresford	*The Camberwell Miracle*	224
Ambrose Bierce	*In the Midst of Life*	199
Phyllis Bottome	*The Mortal Storm*	512
	Private Worlds	107
Ernest Bramah	*Kai Lung's Golden Hours*	174
	The Wallet of Kai Lung	39
	Kai Lung Unrolls His Mat	108
Ann Bridge	*Peking Picnic*	171
Joanna Cannan	*High Table*	213
G. K. Chesterton	*Man Who Was Thursday*	95
Susan Ertz	*Madame Claire*	4
	Now East, Now West	106
Rachel Ferguson	*Brontës Went to Woolworth's*	245
C. S. Forester	*The Gun*	229
E. M. Forster	*A Passage to India*	48
Crosbie Garstin	*The Owls' House*	28
Stella Gibbons	*Cold Comfort Farm*	140
Graham Greene	*It's a Battlefield*	257
Jaroslav Hasek	*The Good Soldier Schweik*	537
Ian Hay	*" Pip "*	211
	A Safety Match	43
Ernest Hemingway	*A Farewell to Arms*	2
Constance Holme	*The Lonely Plough*	47
	Crump Folk Going Home	244
Claude Houghton	*Chaos is Come Again*	178
W. W. Jacobs	*Deep Waters*	104
	Many Cargoes	214
M. R. James	*Ghost Stories of an Antiquary*	91
Stephen Leacock	*Literary Lapses*	212
Eric Linklater	*Poet's Pub*	3
Rose Macaulay	*Crewe Train*	175
Denis Mackail	*Greenery Street*	87
Ethel Mannin	*Children of the Earth*	112
	Ragged Banners	177

FICTION LIST

UNDER AUTHORS' NAMES

J. C. Masterman	*Fate Cannot Harm Me*	252
J. B. Morton (Beachcomber)	*The Barber of Putney*	246
R. H. Mottram.	*The Spanish Farm*	52
Beverley Nichols	*Self*	138
Oliver Onions	*Widdershins*	222
Llewelyn Powys	*Ebony and Ivory*	225
D. Kilham Roberts (editor)	*Penguin Parade (7 Vols.)*	
E. Arnot Robertson	*Ordinary Families*	191
Rafael Sabatini	*Bardelys the Magnificent*	208
	The Tavern Knight	243
Antoine de Saint-Exupéry	*Night Flight*	182
"Saki" (H. H. Munro)	*Selected Stories*	184
William Saroyan	*The Daring Young Man*	201
Olive Schreiner	*Story of an African Farm*	197
Graham Seton	*The W Plan*	50
Beatrice Kean Seymour	*Youth Rides Out*	102
"Shalimar"	*A Windjammer's Half Deck*	241
Ignazio Silone	*Fontamara*	143
Osbert Sitwell	*Triple Fugue*	248
Alan Steele (editor)	*Selected Modern Short Stories (1)*	96
	Selected Modern Short Stories (2)	170
Ralph Straus	*Unseemly Adventure*	167
Tchehov	*Tales from Tchehov*	180
Angela Thirkell	*Wild Strawberries*	93
Ben Travers	*A Cuckoo in the Nest*	44
Robert Tressall	*The Ragged Trousered Philanthropists*	251
Doreen Wallace	*Barnham Rectory*	192
Hugh Walpole	*Mr. Perrin and Mr. Traill*	132
Evelyn Waugh	*Black Mischief*	179
	Decline and Fall	75
	Vile Bodies	136
Mary Webb	*Gone to Earth*	9
Antonia White	*Frost in May*	206
Henry Williamson	*Tarka the Otter*	81
P. G. Wodehouse	*My Man Jeeves*	27
Francis Brett Young	*The Crescent Moon*	172

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